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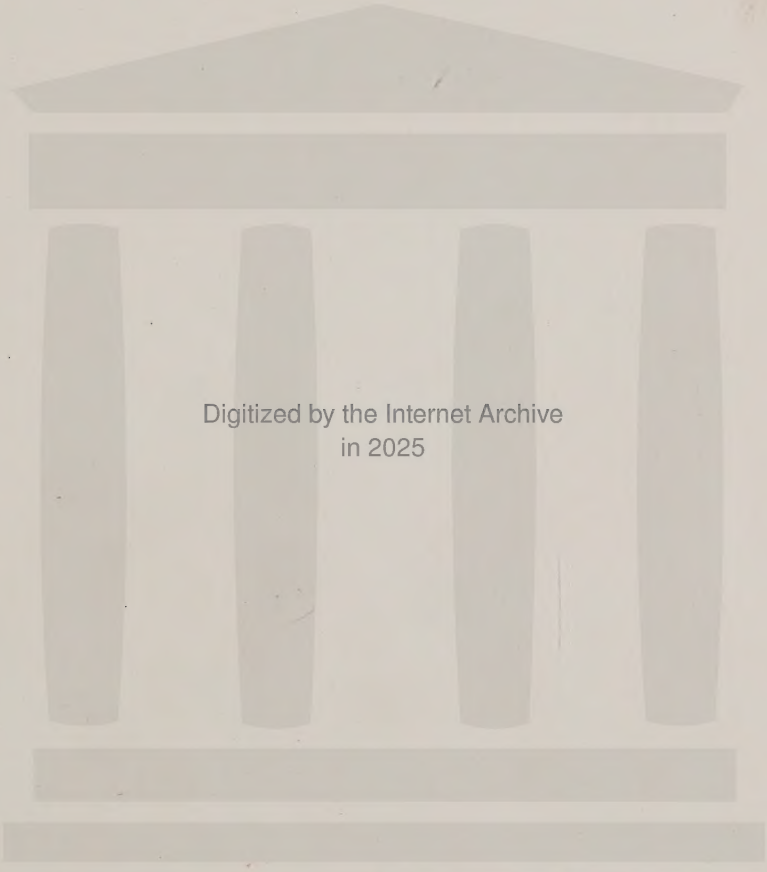
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ERRATA.

Page 31, line 40, for " IIte. Abt., i " read " IIte. Abt., 1."
,, 38, line 28, page 39, legends for figs. 4 & 5, page 40, line 18 & page 41,
,, ,, line 7, for " *Opius agreutretae* " read " *Opius afreutretae* "
,, 40, line 14, for " *Agreutreta discoidalis* " and " *Agreutreta bipunctata* "
,, ,, read " *Afreutreta discoidalis* " and " *Afreutreta bipunctata* "
,, 75, line 35, for " *Caryea* " read " *Careya* "
,, 77, line 41, for " *Anomalacoccus* " read " *Anomalococcus* "
,, 78, line 3, for " *nyemtauras* " read " *nyemitaurus* "
,, 78, line 22, for " *Asympieseilla* " and " *Gracillaria* " read " *Asympiesiella* " and " *Gracilaria* "
,, 160, line 23, for " *anfructuosum* " read " *anfractuosum* "
,, 179, 8 lines from end, for " *Oxpleurites* " read " *Oxypleurites* "
,, 198, line 30 & page 201, line 15, for " R. Mayne " read " R. Mayné "
,, 263, line 23, for " **Tanyrrhynchus** " read " **Tanyremnus** "
,, 268, line 28, for " G. Frenchini " read " G. Franchini "
,, 311, line 25, for p. 000 " read " p. 363 "
,, 314, 3 lines from end, for " *Aelothrips* " read " *Aeolothrips* "
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POECILOSCYTUS COGNATUS, FIEB. (HEMIPTERA, MIRIDAE) AS A SERIOUS PEST OF SUGAR-BEETS.

By N. S. DEKHTIAREV,

Entomologist of the Central Station for the Protection of Plants in Ukraine.

Poeciloscytus cognatus, Fieb. (fig. 1) has already been recorded as injuring sugar-beet in Ukraine. In the summer of 1926 an enormous number of these bugs appeared quite unexpectedly in the districts of Poltava and Kharkov and caused great losses. Much attention has been given to methods of control on the plantations, but the following information is only of a preliminary nature and refers partly to the phenology of the insect.

Fig. 1. *Poeciloscytus cognatus*, Fieb., greatly enlarged (natural size 3·5–5 mm.).

The first appearance in numbers of the light green nymphs of this bug was noticed in the middle of May, and they were observed principally in cracks in the ground, under lumps of earth, on weeds, and also on the beet plants. At the end of May

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about fifteen insects were found on each plant. The half-grown nymphs were chiefly sitting on the undersides of the leaves, where they sucked the juices of the plants. On account of this sucking the leaves gradually wrinkled and withered, until the whole plant dried up (fig. 2). The fields had consequently to be resown several times. The adult insects began to appear in the end of May and were at their height in the middle of June. From 18th to 20th June their numbers began to decrease, and by the end of this month only isolated specimens could be found. The half-grown nymphs of the second generation were noticed in numbers in July, but they did comparatively little harm; for although the leaves showed signs of injuries, yet they did not die.

So far, the life-cycle of this insect under the conditions in Ukraine has not been completely studied. In 1926 its appearance was quite unexpected, and owing to this only partial observations could be carried out. Nor is it certain that the investigations can be continued this year, as the bug usually disappears as unexpectedly as it appears.

Fig. 2. General view of beet plant damaged by *Poeciloscytus*.

I am in no doubt that the insect winters in the egg stage. Its connection with weeds was observed quite clearly: in well cultivated fields the bugs rarely appeared, whereas in those plots where weeds such as *Chenopodium*, *Atriplex* and *Salsola* grew in abundance, the beet nearly completely perished. It is therefore probable that the damage resulted from the bugs laying their eggs on these weeds. This is also suggested by the fact that beets which were planted after the winter crop were practically unharmed, whereas of those sown in the fallow, which was by no means free from these weeds, on the average more than half were lost. From this it seems evident that one of the most effective measures for controlling the bugs consists in the destruction of these weeds, which should be done in the autumn. Another method is to sow the beets as early as possible, because the plants will thus be stronger when the bugs appear and better able to resist their attacks, whereas younger plants will mostly be killed. It is not advisable to hoe up the weeds among young beets after the bugs have hatched for this merely drives the bugs on to the beet plants,

and it has been found that such hoeing has greatly increased the damage and has led to the destruction of more than half, and sometimes even the whole, of the harvest. Therefore, hoeing should in no case be carried out in infested fields as the bugs themselves will destroy the weeds.

Spraying with a solution of soft soap or with kerosene emulsion gives good results, by killing the nymphs ; a somewhat greater concentration of the solution is necessary to kill the adult insects. Many of the bugs, however, escape destruction by keeping under cover of the leaves, in cracks in the earth and so on. A much better result is obtained if the nozzles of the sprayers are directed obliquely and not straight downwards. Good results were also obtained in the destruction of the nymphs by dusting with sulphur powder. This method has been fully described by H. J. Reinhard* and need not therefore be explained here ; under our conditions it needs further testing. But both spraying and dusting are too expensive to be used on the large scale that would be necessary in Ukraine. Therefore under these conditions a special apparatus is mostly employed to catch the harmful insects on beet, especially Halticid beetles. This consists of a wooden board of about two or three metres in width, with a wheel at each end of about 50 centimetres in diameter. A piece of stout cloth in the form of an apron is nailed on behind the board, the lower edge nearly touching the surface of the ground. The lower side of the board is smeared with molasses, which the planters always have on hand. Tangle-foot, of course, acts still better, but it is not always within their reach. The insects, disturbed by the apron, jump from the leaves and stick to the board. They are cleared off with a knife from time to time, together with the molasses, and the board is then re-smeared. The rate of movement with this apparatus is about fifty metres a minute. In testing this machine for the destruction of the bug, it approximately gave the same results as for the Halticids : one kilometre, on the average, yielded 4,500 adult bugs. The results with the nymphs were much less satisfactory, not more than 1,000 insects being caught to the kilometre. Even in the latter case the fields that were treated with the machine presented a much better appearance than did those where nothing had been done. On an average three hectares a day can be covered by the machine, and it should be used only on clear sunny days, when the insects are especially active.

* " The Cotton Flea Hopper." Texas Agric. Exp. Stn., Bull. 339, 1926, pp. 35–37.

ON THE VARIATIONS OCCURRING IN *AËDES ARGENTEUS*, POIRET, IN LAGOS, NIGERIA.

By Sophia L. M. Summers Connal, M.B.E., M.A., B.Sc.,
The Medical Research Institute, Lagos.

(Plate I.)

Aëdes argenteus, Poiret, is a very variable mosquito, and it was thought that it would be interesting to examine a number of freshly-hatched and therefore undamaged specimens and to note how many conformed to the original description. No difficulty was experienced in obtaining the necessary material, as collections of larvae are received daily from the Medical Officer of Health. One thousand of each sex of the species were mounted in the order of their emergence from the pupal case and were examined under the binocular microscope. The one constant feature was found to be the lyre-shaped marking on the thorax, although even here the outline and the centre lines varied in breadth and in colour, and the centre lines varied in length. But as the abdomen and the hind tarsus showed the greatest variations, the present paper is restricted to a description of these.

The Abdomen (Plate i).

There were specimens with the abdomen entirely black, except for the lateral spots. Again, there were many which had the abdomen completely covered with pure white scales. In others, white or yellow scales were scattered generally over the abdomen, so as to give a brindled appearance. Some examples had both apical and basal bands, some had basal bands only, and others had apical bands only. The bands varied in breadth within wide limits. Many of the basally-banded examples had a narrow band of, perhaps, 2 or 3 rows of scales on the second and third segments, which increased to 5 rows on the fourth and fifth segments. Some had broad bands on every segment and others had narrow bands of only one row of scales. The first segment of the abdomen was entirely black in some cases and completely white or yellow in others.

In some individuals there was a triangular median spot on the first abdominal segment, the colour of which was white or yellow. The lateral spots varied in size and occasionally they were purple in colour. The seventh segment usually had one row of yellow apical scales, but sometimes this whole segment was covered with white or yellow scales, and in a number of instances the coloured scales formed a triangular patch. The ground-colour of the abdomen was not always black, and different shades of brown occurred.

The Hind Tarsus.

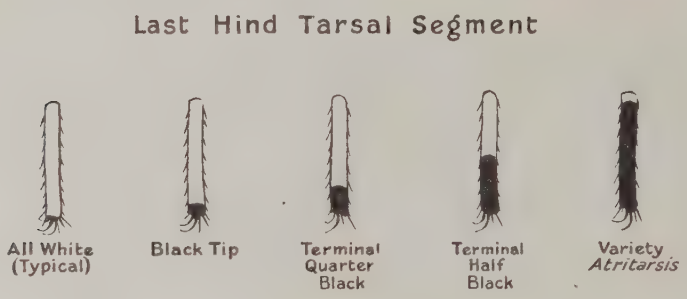
In a large number, the last segment of the hind tarsus was, typically, all white. In others the tip was black, and in others again the terminal quarter or the terminal half was black. Several specimens with the white band on the last segment reduced to a mere spot, were thought to be the variety *atritarsis*, Edwards.

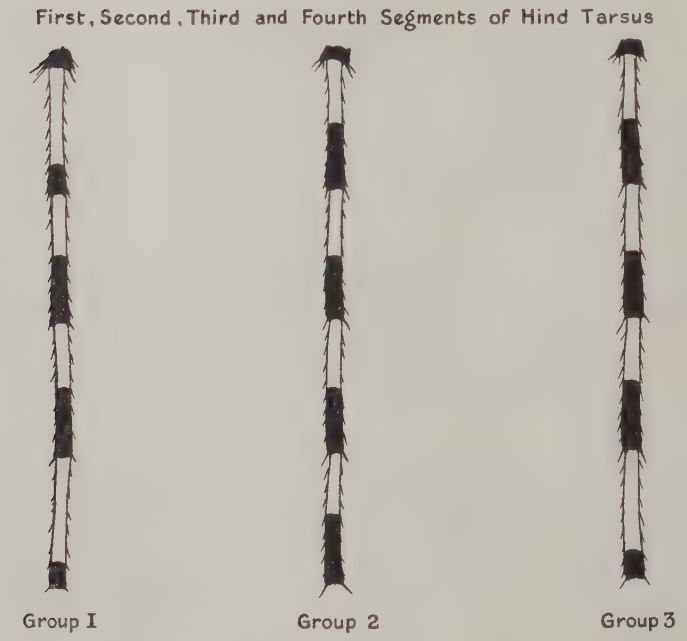
The length of the fourth segment varied. In some cases it was short, being just a little longer than the fifth segment, while in other specimens it was almost twice as long.

The breadth of the white band on the fourth segment varied between two extremes, on the one hand leaving the distal end black, and on the other hand being reduced to a white basal spot. In some instances the white band was a quarter, in others a half, and in some it was three quarters the length of the fourth segment.

But, notwithstanding variations in the length of the fourth segment, the relation of its white band to those on the first, second and third segments, as described in the following paragraph, was constant.

The breadth of the white band on segments 1, 2, 3 and 4, varied in the relation of one or more to the others. Typically, according to the description, each of the first four segments of the hind tarsus has a white band of equal breadth. Two variations, however, excluding var. *atritarsis*, occur quite commonly. In one, the breadth of the band on the fourth segment is about double that of each of the first, second and





third segments. In the other, the band on segment 4 equals that on segment 1 in breadth, and each is double the width of the band on segment 2 and segment 3.

The colour of these bands was almost constantly white, but in one or two cases it was yellow. The ground-colour of the hind tarsi was frequently brown instead of black.

Analysis of Female Specimens.

In the 1,000 females there were 689 (68·9 per cent.) with typically basally-banded abdominal segments. Of this number, 390 (39 per cent.) had the last segment of the hind tarsus white. The remaining 299 had the last segment of the hind tarsus with a black tip, or the terminal quarter or terminal half black. Therefore, of the typically banded females (*i.e.*, with basal bands on the abdominal segments) there were 56·45 per cent. showing typical markings on the last hind tarsal segment.

Specimens with a brindled abdomen came next in numerical order. These had usually apical as well as basal bands, with a broad median longitudinal band uniting them, the remainder of each segment being dotted with white or yellow scales. The brindled specimens numbered 127. Of that number, in 81 the last segment of the hind tarsus was white, that is 63·78 per cent. In 46 the last segment of the hind tarsus showed the variations described in the first group.

Individuals with both apical and basal bands were third in frequency, numbering 110. They showed no white or yellow scales elsewhere on the abdomen. In 67 the last hind tarsal segment was all white, that is, 60·90 per cent., the remaining 43 showing the variations in the last hind tarsal segment already described. The breadth of the abdominal bands in this third group varied greatly. In some the apical band consisted of only one row of scales, and in others there were 3 or 4 rows in the band. In some instances both the apical and the basal bands were so broad that only a narrow black strip was left between them. It was seldom that the apical and the basal band were equal in breadth.

The most interesting and beautiful group consisted of those that had the abdomen covered with white scales. Occasionally a specimen showed a few black scales among the white, and including these there were 40 in the " white abdomen " group. Of these, 26 had the last hind tarsal segment white. There were no examples of *atritarsis* in this group, but in several the terminal half and in others the terminal quarter of the last hind tarsal segment was black.

The fifth group contained the specimens in which the abdomen was entirely black. There was no question of the bands having been rubbed off ; each specimen was perfect and intact. The scales were all black or purplish black. With the light at a certain angle it was sometimes possible to trace a purple basal band on the black background. The lateral spots on the abdomen of members of this group were usually white, but in one or two cases they were purplish black. The group was made up of 25 individuals, 17 of which had the last hind tarsal segment all white. In the remaining 8, some had the last hind tarsal segment half black, but there were no examples of var. *atritarsis*.

The last and smallest group was formed by 9 individuals which had apical but no basal abdominal bands. The banding on the segments was narrow, with usually only one row of white or yellow scales in each. Two of these had the last hind tarsal segment white. The remaining 7 nearly all had the terminal half of the last hind tarsal segment black.

Table I condenses the foregoing information.

TABLE I.

Basally banded	689	Last hind tarsal segment white			390
Brindled	127	,,	,,	,,	,,	81
Apically and basally banded	110	,,	,,	,,	,,	67
White	40	,,	,,	,,	,,	26
Black	25	,,	,,	,,	,,	17
Apically banded	9	,,	,,	,,	,,	2
	1,000					583

Analysis of Male Specimens.

The largest group consisted, as it did in the females, of those insects with a basally banded abdomen. They numbered 852, a much larger proportion than was found in the females. Of this number, 477 had the last hind tarsal segment white.

The second largest group was formed by those with an apically and basally banded abdomen, thus differing from the females, in which the second group consisted of those with a brindled abdomen. There were 74 in this second group, and of these, 49 had the last hind tarsal segment white.

The third group comprised the brindled specimens, of which there were 46, and amongst these there were 25 with a white last hind tarsal segment.

Specimens with the abdomen entirely white formed, as they did in the case of the females, the fourth group. They numbered 21 and included 15 with the last hind tarsal segment white.

The black abdomen group was made up of 7 individuals, 4 of which had the last segment of the hind tarsus white.

The sixth group, the apically banded of the females, was unrepresented in the males.

Table II gives the figures.

TABLE II.

Basally banded	852	Last hind tarsal segment white			477
Apically and basally banded	74	,,	,,	,,	49
Brindled	46	,,	,,	,,	25
White	21	,,	,,	,,	15
Black	7	,,	,,	,,	4
	1,000				570

It will be seen that in the females a typically marked abdomen was found in 68·9 per cent. of the specimens examined. A typical last hind tarsal segment occurred in 58·3 per cent. A typical abdomen and typical last hind tarsal segment together occurred in only 39 per cent.

The following figures show the frequency of typical markings on the last hind tarsal segment in the several atypically ornamented abdomens, in the females :—

Basally banded	56·60 per cent.
Brindled	63·70 per cent.
Apically and basally banded ...	69·90 per cent.
White	65 per cent.
Black	68 per cent.
Apically banded	56·60 per cent.

In the males, 85·20 per cent. showed a typically marked abdomen and 57 per cent. showed a typical last hind tarsal segment. A typical abdomen and last hind tarsal segment together were found in 47·70 per cent.

The percentage of typical markings on the last hind tarsal segment, in the different groups of atypically marked abdomens, in the males is shown below (as in the list for the females, the figures for the basally banded are given as well) :—

Basally banded	55·98 per cent.
Apically and basally banded ...	66·21 per cent.
Brindled	54·34 per cent.
White	71·42 per cent.
Black	57·01 per cent.

Markings on the Hind Tarsal Segments.

The marking on the last hind tarsal segment has already been dealt with. As regards the markings on the first four segments of the hind tarsus, there were three distinct groups.

The most frequent arrangement was that the band on the second segment was equal in breadth to that on the third segment; the band on the first segment was also equal to that on the fourth, but each of these was double the breadth of the band on the second or third segments (Group 1). Another arrangement was that the bands were all of the same breadth on each of the four segments (Group 2). The least common arrangement was that the bands of the first, second and third segments were all equal in breadth, but the band on the fourth segment was double the breadth of each (Group 3).

In Group 1 there were	529	males and	519	females.	
,, ,, 2 ,,	,, 417	,,	,, 236	,,	
,, ,, 3 ,,	,, 47	,,	,, 238	,,	
Markings of var. *atritarsis*	7	,,	,, 7	,,	
	1,000		1,000		

It should be understood that in any two members of the same group, the hind tarsal bands of the one are not necessarily of the same breadth as the bands of the other, although they bear the same relation. For instance, in Group 2, the bands on the four segments are equal in breadth, but in one individual they may be narrow and in another individual they may be broad.

Breeding Experiments.

Experiment 1.—Female with white abdomen, male with basal bands; last hind tarsal segment in both, all white; banding of first four tarsal segments conformed to Group 1 in the female and Group 2 in the male. Sixteen adults were obtained, 10 females and 6 males.

In the females the abdomen was basally banded in 5, brindled in 3, apically banded in 1, and white in 1.

In the males the abdomen was basally banded in 2, brindled in 2, apically banded in 1, and white in 1.

Thus the abdominal markings of the male parent were reproduced in 7 of the progeny, of the female parent in 2, while 7 showed the markings of neither parent.

The hind tarsal markings belonged to Group 1 in 7 female and 2 male offspring, and to Group 2 in 3 females and 4 males. They were thus rather evenly divided, 9 favouring the female and 7 the male parent. The last hind tarsal segment had a black tip in 3 males and 1 female, was all white in 3 males and 8 females, and was half black in 1 female.

Experiment 2.—Female with white abdomen, male apically and basally banded; last hind tarsal segment all white in female, with black tip in male; banding of first four hind tarsal segments belonged to Group 2 in both cases. Six adults hatched out, 1 female and 5 males.

In the males the abdomen was apically and basally banded in 3, white in 1, and brindled in 1.

In the single female the abdomen was apically and basally banded.

The hind tarsal markings belonged to Group 2 in 3 males and 1 female, and to Group 1 in 2 males. The last hind tarsal segment was all white in 3 males and had a black tip in 2 males and in the female.

Experiment 3.—Female with white abdomen, male with broad white basal bands ; hind tarsal segments belonged to Group 2 in the female and Group 1 in the male ; the last hind tarsal segment was black-tipped in the female, and the terminal half was black in the male. Thirteen adults hatched out, 5 females and 8 males.

In the females, all had both apical and basal bands, but in 3 the colour was yellow, not white.

In the males, the abdomen was apically and basally banded in 4, basally banded in 2, and brindled in 1. In the remaining male, in addition to basal banding, there were a few white apical scales on each segment. In the basally banded specimens all the bands were white and were very narrow.

The hind tarsal segments belonged to Group 2 in 7 males and all the females, and to Group 1 in the case of one male. The last hind tarsal segment had a black tip in 6 males and 3 females, it was all white in 1 male, had the terminal half black in one male, and the terminal quarter black in 2 females.

Experiment 4.—Female with white abdomen, male brindled ; hind tarsal segments belonged to Group 1 in the female and to Group 2 in the male ; the last hind tarsal segment was half black in the female, and had a black tip in the male.

Two adults hatched out, both females. One had broad basal bands and the other had a white abdomen. The last hind tarsal segment in both was black-tipped and the hind tarsal segments fell into Group 2 in both.

Experiment 5.—The parents both hatched out in Experiment 1. The female had narrow basal bands on the abdominal segments and the male had a white abdomen ; the hind tarsal segments came into Group 1 in both cases ; the last hind tarsal segment in the female was all white, and was black tipped in the male. Seven adults were obtained, 3 females and 4 males.

In the females the abdomen had narrow basal bands in 2 and was brindled in 1.

In the males the abdomen was apically and basally banded in 3 and white in 1.

Thus two females but no male offspring had the abdominal markings of the female parent, while only one male and no female offspring had the abdominal marking of the male parent.

Only one male and one female offspring came into the parents' group (Group 1) as regards the markings on the hind tarsal segments. All the others came into Group 2. The three female offspring followed the female parent in having the last hind tarsal segment all white, as did also one male offspring. In the other three males the terminal half was black in two and had a black tip in one.

Experiment 6.—Here also, parents obtained from Experiment 1. Both had narrow basal bands on the abdomen, and both had the last hind tarsal segment white ; in the female the hind tarsal markings came into Group 2 and in the male into Group 1. Three adults hatched out, 2 males and 1 female.

All had narrow basal abdominal bands. In the male offspring the hind tarsal markings were the same as those of the male parent (Group 1), and in the single female offspring the markings were those of the female parent (Group 2). One male had the terminal half of the last hind tarsal segment black, the other had a black tip, and in the female it was all white, as in the case of the parents.

Experiment 7.—Parents again came from Experiment 1. Both had a brindled abdomen ; the female had the last hind tarsal segment all white, and in the male it had a black tip ; the markings of the hind tarsal segments came into Group 1 in the female and Group 2 in the male.

Only one adult was obtained, a female. The abdomen was basally banded, the bands being narrow. The tip of the last hind tarsal segment was black, as in

the male parent, and the banding on the hind tarsal segments brought it into Group 2, also as in the male parent.

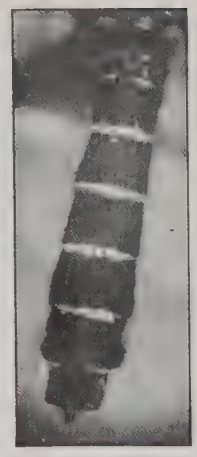
Several attempts were made to obtain adults of the next generation, but the females invariably died before oviposition. The experiments, however, are being continued and extended.

Although it seemed clear that light and shade, and different colours of the breeding dishes were unconnected with the variations of the markings, several experiments were carried out with this possibility in view. A pure white, an unrelieved black and a reddish brown environment for the larvae were used. The white breeding dishes yielded no more adults with predominating white ornamentation than did the black dishes, nor did the black dishes give more darkly marked specimens than the white ; neither did the reddish brown dishes appear to have influence on the markings.

There appears to be no justification for describing new varieties of *Aëdes argenteus* from any of the specimens examined. The findings recorded are given in the hope that they will tend to discourage the naming of new varieties.

Entirely black.

Basal banding.



Apical banding.

Basal and apical banding.

Brindled.

White.

Variations in the colour of the abdomen of *Aëdes argenteus*, Poiret.

ON THE EFFECT OF METHODS OF MECHANICAL CONTROL ON THE PROGRESS OF INTRODUCED PARASITES OF INSECT PESTS.

By W. R. Thompson, Ph.D., D.Sc.

The importation of parasites from the native home of introduced insect pests now constitutes a recognised part of entomological practice in most countries under civilised control. However, since the method is still in the experimental stage, and since long periods of time often elapse before the parasites colonised become sufficiently abundant to exert any appreciable influence on the host, the entomologist often finds it necessary, in order to avert disaster, to utilise remedies which, though temporary, are more immediately effective. To this end he employs some one or other of the various methods of mechanical control, by which the population of the insect pest can be at once greatly reduced.

But in many cases, these methods of attack affect the parasites as well as the hosts. It is therefore important to consider what influence they will have upon the progress of the natural enemies and whether, in order to obtain the temporary relief afforded by mechanical methods, we are not sacrificing the hope of permanent control.

We have at present no data permitting us to attack this problem from the experimental angle; but it can be studied in a broad general way when reduced to mathematical terms.

In order to deal with the problem we must consider: the initial numbers of reproducing parasites and hosts present at the beginning of the experiment, the effective rates of reproduction and sex ratios of the two species and the proportions of each eliminated by the mechanical method utilised before the period of reproduction.

Let the total number of female hosts present at the beginning of the period studied be$=n$, and the total number of female parasites present at the beginning of this period be$=p$.

Let the number of adult female progeny normally produced by each host$=h$, and the number of adult female progeny normally produced by each parasite$=s$.

The total number of adult hosts, including both sexes, normally produced by each female host will thus be$=hl$, where l is a numerical factor equal to or greater than 1, and, similarly, the total number of adult parasites, including both sexes, normally produced by each female parasite will be$=sf$, where s is a numerical factor equal to or greater than 1.

The increase of the parasite from generation to generation depends obviously upon the number of females produced, but the number of hosts destroyed depends on the total number of parasites of both sexes, since a male parasite destroys its host just as efficiently as a female parasite.

Let the proportion of individuals of the parasite population eliminated by mechanical methods of control before the period of reproduction be $=(1-w)$, the proportion surviving being thus$=w$, and the proportion of unparasitized individuals of the host population eliminated be$=(1-v)$, the proportion surviving to reproduce being$=v$.

It can then be shown, that at the beginning of the tth generation, the number of hosts and parasites present will be given by the following equations:—

$$H_t = v^{t-1}nh^tl - v^{t-1}psfh^{t-1} - v^{t-2}wps^2fh^{t-2} \ldots\ldots\ldots\ldots\ldots \text{(to } t \text{ terms)} \ldots\ldots\ldots (1)$$

$$P_t = w^{t-1}ps^tf \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Now the effective rate of reproduction of the parasite may be less than, equal to, or greater than, that of the host. By mathematical methods, which it is not necessary to give here, it can be shown that when the initial number of parasites is

small as compared with the initial number of hosts and the effective reproductive rate of the parasite equal to or less than that of the host, control either will be impossible or will occur only after so long a period that its possibility is of no practical interest. It will therefore be sufficient, for the purpose of this paper, to consider cases in which the reproductive rate of the parasite is superior to that of the host.

We may therefore put

$$s=ah, \text{ } a \text{ being} > 1.$$

Let us suppose, for the sake of simplicity, that the sex ratios are the same in parasite and host. In this case, the symbols f and l will eventually disappear from the formulae and can therefore be neglected. The equations (1) and (2) thus become

$$H_t=v^{t-1}nh^t-v^{t-1}pah^t-v^{t-2}wpa^2h^t-v^{t-3}a^2pa^3h^t \text{ .....to } t \text{ terms .....} (3)$$
$$P_t=w^{t-1}pa^th^t \text{ .....} (4)$$

Now the mechanical methods employed against the host insect will produce an elimination of the host less than, equal to, or greater than, the elimination of the parasite. We shall thus have

$v=kw$, where the proportion of hosts escaping is greater than that of parasites escaping ;

$v=w$, where the proportions of hosts and parasites escaping are equal ; and

$w=kv$, where the proportion of parasites escaping is greater than that of hosts escaping, with, in all three cases

$$k > 1.$$

Substituting in the formulae, we obtain the three following sets of equations :—

$$H^t{}_1=nk^{t-1}w^{t-1}h^t - k^{t-1}w^{t-1}pah^t - k^{t-2}w^{t-1}pa^2h^t - k^{t-3}w^{t-1}pa^3h^t - \text{.....}$$
$$\text{.....(to } t \text{ terms).....} (5)$$
$$P_{t_1}=w^{t-1}pa^th^t \text{ .....} (6)$$
$$H_{t_2}=w^{t-1}nh^t - w^{t-1}pah^t - w^{t-1}pa^2h^t - w^{t-1}pa^3h^t \text{..... (to } t \text{ terms) .....} (7)$$
$$P_{t_2}=w^{t-1}pa^th^t \text{ .....} (8)$$
$$H^t{}_3=v^{t-1}nh^t - v^{t-1}pah^t - v^{t-1}kpa^2h^t - v^{t-1}k^2pa^3h^t \text{ ..... (to } t \text{ terms) .....} (9)$$
$$P^t{}_3=k^{t-1}v^{t-1}pa^th^t \text{ .....} (10)$$

A special subdivision of the first case treated ($v=kw$) occurs when we have $a=k$, *i.e.*, when the ratio between the reproductive rates of host and parasite has exactly the same value as the ratio between the proportions of host and parasite escaping destruction. The first set of equations then becomes,

$$H_{t_{11}}=a^{t-1}w^{t-1}h^t[n-pa] - pa^th^tw^{t-1}[1+1+ \text{ ..... to } (t-2) \text{ terms}] \text{ ..... } (11)$$
$$P_{t_{11}}=w^{t-1}pa^th^t \text{ .....} (12)$$

In order to determine the effect produced by the elimination of part of the host and parasite populations by mechanical methods, it will be sufficient to compare the time required for the increase of the parasite population to the point of total control (100 per cent. parasitism) in the various cases mentioned, with the time required when no elimination by mechanical methods occurs.

By a series of simple transformations which have been explained in earlier papers, we obtain for the time required for control, in generations, the following equations :—

$$t=\frac{Log\left\{\frac{na-n+pa}{pa}\right\}}{Log\ a} \text{ .....} (13)$$

when there is no elimination by mechanical methods ;

$$t_1=\frac{Log\left\{\frac{pak+na-nk}{pak}\right\}}{Log\ \frac{a}{k}} \text{ .....} (14)$$

where the proportion of hosts escaping elimination by mechanical methods is greater than the proportion of parasites escaping ($v=kw$) ;

$$t_{11} = \frac{n}{pa} \qquad \text{..... (15)}$$

where $v=kw$ and $k=a$;

$$t_2 = \frac{Log \left\{ \frac{na - n + pa}{pa} \right\}}{Log\ a} \qquad \text{..... (16)}$$

where the proportions of host and parasite eliminated are equal ($v=w$) ;

$$t_3 = \frac{Log \left\{ \frac{nka - n + pa}{pa} \right\}}{Log\ ka} \qquad \text{..... (17)}$$

where the proportion of hosts escaping elimination is less than the proportion of parasites escaping ($w=kv$).

The formulae for t and t_2 are identical. This shows that, as we might expect after a little careful reflection, the elimination produced by mechanical methods has no effect whatever upon the time required for control, provided that the proportions of hosts and parasites destroyed are equal.

Now unless the distribution of host and parasite throughout the environment is different, and the difference such that the employment of mechanical methods will affect one more than the other, the use of these methods in areas into which parasites have been introduced will thus have no effect upon their progress, although it will have a positive and beneficial effect by reducing the total population of the host and thus leaving less individuals to destroy the crop or to multiply in the following generation. For example, the destruction of stalks after the harvesting of the corn crop, in order to combat the European corn borer (*Pyrausta nubilalis*, Hübn.), can be recommended even in areas into which the parasites of this insect have been introduced, provided that the parasite population of the infested zone is not completely exterminated. On the other hand, as extermination of such introduced pests is desirable along the outer borders of the infested areas and in small, isolated infestations, the introduction of parasites should not be attempted in such districts, but only where the pest is already well established and extermination no longer a practical possibility.

We may now consider cases in which the relative destruction of hosts and parasites produced by mechanical methods of control is unequal. Let us suppose, for example, in the case of the European corn borer, that a migration of caterpillars from the overwintering maize stalks occurs after the parasite larvae have emerged from their hosts, but before they have transformed and issued as adults, and that the migrating caterpillars establish themselves in places where they are safe from destruction. In this event the use of mechanical methods would result in the destruction of many more parasites than hosts. On the contrary, if the destruction of the stalks was carried out after the issuance of the adult parasites, but before that of the moths of the host, and if no marked migration of the caterpillars of the latter occurred after the emergence of the parasite larvae, the proportion of hosts eliminated would be greater than the proportion of parasites.

A simple inspection of the equation (14) for t_1 shows that it can be solved only when we have $a > k$, which means that when the elimination of parasites, as compared with hosts, rises above a certain point, the advantage in reproductive rate possessed by the parasite is annulled, so that it falls to the position of one whose reproductive power is less than that of the host, in which case, as already stated, control will ordinarily be a practical impossibility.

Put, now, in the equations for t and t_1 (13 and 14), $n=100{,}000$, $p=10$ and $a=4$, giving to k, in the equation for t, a series of values all less than that of a. We have then for t and t_1 the following values :—

k	1·0	1·5	2·0	2·5	3·0	3·5
t	6·4	—	—	—	—	—
t_1	6·4	8·5	11·2	15·5	23·5	44·8

As the figures show, the number of generations necessary for the control of the host (100 per cent. parasitism) under the conditions mentioned, rapidly increases as the value of the ratio between hosts escaping and parasites escaping rises. Thus, only 2 more generations are required for control when 1·5 times as many hosts as parasites escape, but when 3·5 times as many hosts as parasites survive, about 38 more generations are necessary before control is obtained.

Thus the employment of measures of mechanical control in a manner in any marked degree favourable to the host would have a disastrous effect upon the progress of the parasite.

An examination of the equation for t_{11} (15) confirms this conclusion. The time required for control under the conditions stated would here be 2,500 generations, *i.e.*, one quarter of the time required for control where there is no elimination and the reproductive power of the parasite is merely equal to that of the host.

Let us take now the case where the proportion of parasites escaping destruction after the use of mechanical methods of control is greater than the proportion of hosts escaping ($w=kv$). Giving to the various symbols the same values as before, we obtain the following results :—

k	10	1·5	2·0	2·5	3·0	3·5
t	6·4	—	—	—	—	—
t_3	6·4	5·2	4·6	4·3	4·1	3·9

The effect of favouring the parasite is thus much less marked than the effect of favouring the host. A rise in the proportion of hosts escaping causes a rapid increase in the time required for control ; but this time is only slightly diminished by an increase in the proportion of parasites escaping.

We may therefore conclude that in areas into which parasites have been introduced, such controlling measures as may be employed ought to be designed so as to eliminate at least as many hosts as parasites ; but that once this result has been secured, it is unnecessary to take any further precautions in order to avoid destroying parasites. Certain observers have claimed that by favouring parasites at the expense of their hosts, remarkable results have been obtained.* Many entomologists of the first rank, as, for example, Comstock and Riley, have strongly deprecated the indiscriminate destruction of insect populations including both parasitized and unparasitized individuals. They have advised that in such cases the hosts be preserved in special containers and destroyed only after the parasites have emerged and escaped. It is of course true that if over the whole infested area the majority of the hosts are destroyed and the majority of the parasites liberated, a definite benefit will result. But as such measures normally affect only a fraction of the insect population and are generally employed in a rather sporadic and half-hearted manner, by a small proportion of the agriculturists of the infested districts, they will in most cases confer only a slight numerical advantage upon the parasite, in which case the progress of events will not be materially affected. Such measures have therefore for the most part little or no real practical value, and as they entail a very considerable expenditure of time and labour they should not be recommended by entomologists unless their value has been demonstrated by careful experiment.

(*) For a rather full discussion of this phase of parasite work, see L. O. Howard & W. F. Fiske, Bull. 91, U. S. Bur. Entomology, pp. 18–20.

MOSQUITO BREEDING IN "TEST" WATER-CONTAINERS.*

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During the six-month period from December 1925 to June 1926, some observations were carried out on the mosquito breeding that occurred in a number of "test" water-containers placed in various locations in the compound of the headquarters of the West Africa Yellow Fever Commission at Yaba, near Lagos, Nigeria. The main purpose of these observations was an endeavour to obtain supplemental information on the bionomics of the yellow fever mosquito, *Aëdes* (*Stegomyia*) *aegypti*, Linn., in West Africa.

The Commission Compound.

The Compound, consisting of approximately seven and a half acres, is located at Yaba, about five miles from Lagos and fronting on the Lagos-Ibadan highway. It is bordered on the south by the premises of the Yaba Medical Research Institute, and the habitations at this Institute are the only ones in very close proximity. A large savannah, nearly a half mile in width, with a growth of long grass, small clusters of low bush, and a few trees, lies on the east side. There are no houses on this side within a distance of half a mile. This savannah also extends along approximately half of the north side, the remainder being bordered by a belt of mango, palm, and other varieties of trees, and with a thick undergrowth. On this side there are no houses within a radius of between 400 and 500 yards. The area on the opposite side of the highway in front is covered with long grass, small patches of low bush, and scattered trees. There are no habitations within 300 yards or more in this direction.

The Containers.

Two types of containers, sections of bamboo and tin cans, were used. The bamboos were nearly four inches in width, inside diameter, and cut about seven inches above the node, so that each section would hold more than a pint of water. The tins were of the ordinary type in which vegetables and fruit are usually canned and also with a water capacity of approximately one pint. Ten sets of containers were put out for breeding-places. Each set consisted of the following :—

Container A. Bamboo section filled with tap water and several mango leaves. The latter had been dried for some time before being placed in the water.

Container B. Tin can filled with tap water.

Container C. Bamboo section filled with tap water.

Container D. Tin can with tap water and leaves as in A.

Locations of the containers.

The ten sets of containers were placed about the compound in the following locations :—

Set No. 1. Beneath the laboratory, which was built on cement pillars about three feet in height ; this set was protected from all sunshine.

Set No. 2. Under Dormitory No. 1, the floor of which was also approximately three feet from the ground ; this set, too, was always in the shade.

* The studies and observations on which this paper is based were conducted with the support and under the auspices of the International Health Board of the Rockfeller Foundation.

Set No. 3. In the centre of a small, but thick cluster of trees about 9 yards north of the Staff House ; not exposed to the sun.

Set No. 4. In the thick growth of bush and trees on the north side of the compound ; in the shade. The building nearest this set was the Servants' Barracks No. 1, about 70 yards distant.

Set No. 5. In the centre of a patch of long grass 50 yards east of Servants' Barracks No. 1 ; fully exposed to the sun.

Set No. 6. At the base of a small tree located 60 yards east of set No. 5 and about 75 yards from Dormitory No. 1. About two months after sets 5 and 6 were placed in position a new dormitory was erected between the two which shortened the original distances from habitations. This change placed No. 5 at 28 yards and No. 6 at 22 yards from a dwelling. Set 6 was exposed to the sun the greater part of the day.

Set No. 7. In the edge of a small clump of bushes at the south-east corner of the compound and at a distance of 100 yards from Servants' Barracks No. 2 ; exposed to the sun the greater part of the day.

Set No. 8. In long grass at the base of a small tree 33 yards from the building where monkeys, rabbits, guinea pigs, etc., were housed ; in shade only during the mornings.

Set No. 9. In sparse growth of tall grass, 16 yards from the animal house, on the east side of the compound ; fully exposed to the sun.

Set No. 10. Beneath the animal house ; in the shade.

Since sets Nos. 1, 2, and 3 were beneath buildings they were sheltered from rains ; the others were exposed. With the exceptions of Nos. 3 and 4, which were surrounded by bush sufficiently thick to furnish some protection, all the sets were more or less exposed to any winds that occurred.

Collecting the Larvae.

The containers were examined every five days. In making the examinations the contents of each container were poured into a shallow glass dish. When larvae were not readily observed a piece of white paper was held a few inches beneath the dish as a background against which the small, newly emerged larvae, if present, could be more easily detected.

When larvae were found, the dish of water and the container from which it had been taken were brought to the laboratory. If none were present the water was returned to the container and left until the next examination.

At the laboratory each container was partly filled with tap water, vigorously shaken with a hand held over the top, and then emptied into the dish containing the larvae that had been previously taken from it. This was repeated three times in order to remove any larvae that might be adhering to the container. The inside of the latter was then thoroughly scrubbed with a stiff brush while being held under water running from the tap in order to remove any eggs that might be adherent. If it was an A or D container, each leaf was well shaken in the water in the dish and then replaced in the container after this had been cleaned. The latter was then filled with fresh water and returned to its location in the compound. The leaves were always pushed to the bottom of the container in order to eliminate, so far as possible, the chance of eggs being deposited on them and adhering sufficiently to be carried over from one examination to the next.

The larvae were left in the dishes, with a few bread-crumbs added for food, to develop and pupate. The pupae were removed daily and placed in separate test-tubes to emerge as adults. All larvae collected during the six months of observation were bred out to imagoes, with the exception of probably less than two per cent. that died before reaching the adult stage.

Occurrence of Breeding.

As the containers were placed in the compound on 5th December 1925 and left until 18th June 1926, which period included the latter part of the dry season and nearly half of the wet season, the opportunity was considered favourable for observing the breeding that occurred under the conditions existing in both seasons.

No larvae were found at the first examination. This was on 10th December, only five days after the containers were set out, and it was the only examination at which all the containers gave negative results.

Since the examinations were made and larvae collected at five day intervals, each container was examined 39 times during the period of observation. Thus the maximum number of times that any container could be found with larvae present was 39, while the largest total possible for all 40 containers was 1,560. The actual number of positive collections from all containers was 239. This amounted to 15·32 per cent. of the maximum total if all the containers had been positive at each examination. The container in which larvae were found most frequent, was 7A, which yielded 17 positive collections.

The following table gives the number of occasions on which larvae were found in each container :

TABLE 1.

The Number of Positive Collections from each Container.

Set.	Container A	Container B	Container C	Container D	Total.
1	6	—	4	—	10
2	6	1	4	3	14
3	15	—	12	7	34
4	11	1	10	5	27
5	5	—	6	1	12
6	10	—	9	4	23
7	17	4	11	3	35
8	15	2	12	5	34
9	13	—	13	3	29
10	7	5	5	4	21
Totals	105	13	86	35	239

It may be noted from the foregoing table that a marked preference was shown for the bamboo joints (A and C) as a place of oviposition ; also that larvae were found more frequently in the containers of both types in which leaves were present (A and D) than in those containing water only.

Occurrence of Species.

The adult mosquitoes bred out from the larvae collected during the period of observation totalled 6,590. The species represented, the number of times that each occurred in containers, and the number of adult of each species bred out are shown in Table II.

TABLE II.

Species, Occurrence of each, and Number of Adults bred out.

Species.	Number of times found in containers	Number of adults bred out
Aëdes (Stegomyia) aegypti, Linn.	204	4,508
Culex (Culiciomyia) nebulosa, Theo. ...	16	741
Culex decens, Theo.	6	544
Aëdes (Stegomyia) luteocephala, Newst. ...	30	344
Eretmopodites chrysogaster, Graham ...	22	108
Cyathomyia fusca, Theo.	6	93
Aëdes (Stegomyia) apicoargentea, Theo. ...	9	92
Aëdes (Stegomyia) simpsoni, Theo.	11	92
Culex duttoni, Theo.	1	34
Aëdes (Stegomyia) africanus, Theo.	3	25
Culex tigripes, Grp.	1	6
Megarhinus(Toxorhynchites) brevipalpis,Theo.	2	2
Aëdes (Aëdimorphus) apicoannulatus, Edw.	1	1
Total	——	6,590

Larvae of two or more species were frequently found in a container, *i.e.*, five species associated in a container on one occasion ; four species on two occasions ; three species sixteen times ; two species thirty-four times ; and one species 187 times.

The five species found associated in the container on the one occasion were *Aëdes aegypti*, *Aëdes africanus*, *Aëdes luteocephala*, *Culex nebulosa*, and *Cyathomyia fusca*.

Occurrence of Aëdes aegypti.

Aëdes aegypti greatly predominated in occurrence in the containers and also in the number of adults bred out, more than 68 per cent. of the latter being of this species. It was absent at only six examinations (10th Dec., 19th, 24th, and 29th Jan., and 3rd and 8th March), while at seven examinations (30th Dec., 4th and 14th Jan., 15th, 20th and 25th March, and 4th April) it was the only species represented. The number of times that larvae of this species were found in each of the containers of the ten sets is shown in the following table :—

TABLE III.

The Number of Occasions that Larvae of Aëdes aegypti *were found in each Container.*

Set No.	Container A	Container B	Container C	Container D	Total.
1	3	—	3	—	6
2	5	—	4	1	10
3	13	—	13	5	31
4	6	1	7	2	16
5	5	—	6	1	12
6	9	—	8	4	21
7	14	3	9	1	27
8	14	2	11	5	32
9	13	—	14	3	30
10	6	5	4	4	19
Totals	88	11	79	26	204

Discarded tin cans in compounds are so commonly found to be prolific breeding-places for *A. aegypti* under ordinary conditions that it was somewhat interesting to find such a marked preference shown for the bamboo joints as demonstrated in this observation ; since this species was present in these containers on 167 occasions against 37 in the tins. This was probably due more to the wooden containers being of greater attraction to the females about to oviposit than to any differences in the contents. The smaller amount of breeding in the tins usually resulted in the fact that the water in them was changed less frequently than in the bamboos. This sometimes caused it to be of sufficiently long standing to become somewhat stagnant, with a considerable amount of organic matter present, but never to the extent of becoming very much discoloured or foul smelling. One might expect that this increase of food supply for the larvae would be more alluring to the pregnant females than the fresher water in the wooden containers, but apparently such was not the case.

The construction of the buildings on the compound was begun on 1st October and a number of men were engaged on this work during the day, but, with the exception of a native night watchman, none was present between the hours of 5 p.m. and 7 a.m., until 1st December, when Dormitory 1 was occupied. The other buildings were not inhabited until 23rd December. The containers were put out on 5th December, and larvae of *A. aegypti* were found in two of them (3A and 9C) on 15th December. This would to some extent indicate that only a comparatively short time is necessary for the immigration of this species to breeding-places in new locations This might have been expected had the compound been situated in a more central area and surrounded by habitations ; but since it is in an outlying zone with no other habitations present within a distance of several hundred yards, except on the east side, one would hardly look for this species to put in such an early appearance.

So far as the evidence here collected goes, the distribution of the breeding of *A. aegypti*, as shown in Table III, was somewhat at variance with the commonly accepted opinion that the preferred breeding-places of this species are in the immediate vicinity of habitations. The containers of Set 1 produced no larvae of this species until 19th April, more than four months after being placed beneath the laboratory, and they were found in this set only 6 times during the period of observations. In Set 2, under the dormitory, they were present in only 10 collections. In Set 10, beneath the animal house, they were found 19 times, while in Set 8, only 33 yards away but in the grass and bush, they were represented in 32 collections, which was the highest number for any of the sets. Set 7, situated in the bush 100 yards from the nearest habitation, gave this species in 27 collections. These findings suggest that the ovipositing females were more numerous in the grass and bush growths at a short distance from the houses than they were in the more immediate proximity. This may have been due either to a natural selection for the places of concealment offered by the bush, or to the fact that the principal buildings on the compound were well screened. However, the servants' barracks, kitchen, store-rooms, and garages, were unscreened, and these, as well as the space beneath the buildings, provided plenty of hiding places if propinquity to dwellings was desired.

That a certain amount of seasonal variation occurs in the breeding of *A. aegypti* seems to be shown by the absence of this species from all the containers at five consecutive examinations during the middle of the dry season and the increase that took place with the beginning of the rains.

The rainfall during the period of this observation and the number of collections in which *A. aegypti* was represented in the containers of each set is shown by months in the following table :—

TABLE IV.

The Number of Times that Aëdes aegypti *Larvae were found in each Container in relation to the Monthly Rainfall.*

Month.	Set No.										Monthly Total.	Rainfall (inches).
	1	2	3	4	5	6	7	8	9	10		
Dec. (5th–31st)	—	—	5	—	—	—	—	—	2	4	11	0·10
Jan.	—	2	—	—	—	—	—	—	2	—	4	0·0
Feb.	—	—	2	4	1	2	2	5	2	2	20	2·95
Mar.	—	2	8	3	4	6	6	8	9	—	46	3·80
Apr.	1	—	6	—	—	2	9	7	5	4	34	4·24
May	3	4	6	5	2	6	7	6	7	7	53	7·99
June (1st–18th)	2	2	4	4	5	5	3	6	3	2	36	6·19

Conclusions in regard to Aëdes aegypti.

It would probably be necessary to continue this observation on the breeding occurring in the " test " containers over a period of two years or more before a very definite analysis of the results could be made. However, from a consideration of the data presented in the foregoing tables the following conclusions in regard to *Aëdes aegypti* appear reasonable :—

1. A marked preference is shown for bamboo sections over tin cans as a place of oviposition.
2. Water containing leaves seems to be more attractive to the ovipositing females than water only.
3. Much breeding may occur in containers that are located one hundred yards from a habitation.
4. The females may prefer the places of concealment afforded by grass and bush at a short distance from habitations to those in the more immediate vicinity or inside the houses.
5. A seasonal variation occurs, the prevalence and breeding decreasing during the dry season and increasing with the beginning of the rainy season.

PESTS OF ECONOMIC PLANTS IN SAMOA AND OTHER ISLAND GROUPS.

By G. H. E. Hopkins, M.A., F.E.S.

(Plate II.)

During two years (1924 and 1925) spent in Samoa by Dr. P. A. Buxton and myself, while employed in research on filariasis for the London School of Hygiene and Tropical Medicine, we made notes of such agricultural pests as came our way, though (our main interests being medical) we were not able to investigate them at all thoroughly. For this reason the fact of an insect being recorded only on one occasion is no indication that it did not occur in other months, or even that it was uncommon, since we frequently did not continue to make notes of the occurrence of a species we had once recorded. Though our observations make no claim to completeness, they are perhaps worthy of publication in view of the scarcity of records from this group of islands. Our observations on medical and veterinary entomology have been published as a Memoir of the London School of Hygiene and Tropical Medicine. In that Memoir we have published maps, and short accounts of the structure, flora and climate, of Samoa.

Unless otherwise stated, all records are from Upolu Island, Western Samoa. We also made brief visits to other parts of Samoa and to Tonga and the Ellice Islands; records from these latter groups have been included in the present notes. The majority of Swezey's records quoted below appear to have been made in Tutuila Island, American Samoa, but he frequently does not give the exact locality.

For the identifications of insects I am indebted to Mr. L. Chopard (Orthoptera) Mr. F. Muir (Fulgoroidea), Mr. F. Laing (Aphids and Coccids), Mr. G. F. Hill (Isoptera), Mr. E. Meyrick (smaller Lepidoptera), and the Imperial Bureau of Entomology (remaining groups).

The insects attacking cotton and allied plants are of no present importance in Samoa, but would require attention in the event of the success of the experiments in cotton-cultivation now being carried out there.

ORTHOPTERA.

PHASMIDAE.

Graeffia coccophaga, Newp., is a serious pest of coconuts in some districts, entirely stripping the leaves and leaving only the mid-ribs. They are almost entirely nocturnal in their habits and may easily be collected on the smaller trees by searching for them with a lantern at night. The species is also common in Fiji, Tonga, and other groups of islands in the Pacific. Swezey records the stick-insects he took in Samoa as *G. minor*, Brunner, but Chopard has determined all our specimens as the above species; it is possible that both species occur in the group, as Brunner records *minor* from Samoa as well as from Fiji.

RHYNCHOTA.

PENTATOMIDAE.

Tectocoris lineola, F. var. *tongae*, Boisd. Not found in Samoa but common in Tonga at Vavau and Nukualofa. All stages were found on cotton-plants, attacking the bolls. It is a common pest of cotton in Queensland.

COREIDAE.

Leptocorisa varicornis, F. The adults were found in large numbers on egg-plant at Apia in June 1925; the species is not known as a pest of this plant, but is a widespread and serious pest of rice in other countries. No rice is grown in Samoa at

present, that used by the Chinese coolies being imported, but in the event of rice-growing being attempted in the future this pest would have to be reckoned with.

Leptoglossus australis, F. Common on cucumbers at Apia in February 1925. It passes all stages on the plant.

PYRRHOCORIDAE.

Dysdercus sidae, Montr. Often common on *Hibiscus* spp. and frequently extremely abundant in the Apia neighbourhood on kapok (*Eriodendron* sp.). It also occurred on cotton at Nukualofa, Tonga. *Dysdercus impictiventris*, St., was also captured near Apia on *Hibiscus tiliaceus*.

DELPHACIDAE.

Megamelus proserpina, Kirk. This species was always very common in Samoa wherever taro (*Colocasia esculenta* (L.) Schott) was grown, both at sea-level and at Malololelei (2,000 ft.) but was never found on ta'amu (*Alocosia macrorrhiza* (L.) Schott). In Tonga I did not observe it ; not much taro is grown there, and it appears to be a slightly different variety from that grown in Samoa. The insects congregate in small parties, including both adults and nymphs, on the underside of a leaf, often more than 50 under one leaf. The leaves most affected " scorch " in spots, but as young leaves are not attacked, the damage done is probably very small. We found it in Upolu and Savaii (Western Samoa), and Swezey informs us that he has it from Tutuila (American Samoa) and from Fiji, Java, and the Philippines, but not from Hawaii. As a flightless pest of a common Polynesian food-crop (which is little eaten by Europeans and hence has probably not been spread by commerce of recent years), a study of the distribution of this species might provide very interesting evidence as to the origin and wanderings of the early Polynesians.

Peregrinus maidis, Ashmead. A single male specimen was taken at Apia, March 1924, and determined by Muir. There is no record of this wide-spread pest causing damage in Samoa.

Perkinsiella vitiensis, Kirk. Not very abundant on sugar-cane in the Apia neighbourhood. Sugar-cane is not a very important crop in Samoa, being used chiefly to provide thatching-material. Swezey took *Ootetrastichus beatus*, Perkins, an egg-parasite of this species, on Tau Island, Samoa.

ALEURODIDAE.

The puparia of *Neomaskellia bergii*, Sign., were sometimes found in enormous numbers on the leaves of sugar-cane, and a considerable amount of " scorching " resulted. In Fiji, where sugar is a considerable export, this insect is an important pest.

COCCIDAE.

Asterolecanium bambusae, Bdv., is recorded from Samoa by Doane & Ferris. Buxton obtained it in Efate Island, New Hebrides. In both cases the insects were on bamboo.

Pseudococcus citri, Risso. Of this species we obtained many specimens from various localities in Upolu, Savaii, and Manono, on a variety of food-plants, including lemon-fruits and cashew. In the New Hebrides it is recorded on cotton.

Pseudococcus cocotis, Mask., was found on seedling coconut-stems near Apia, under mud-galleries made by ants.

Pseudococcus calceolariae, Mask., is recorded by Swezey from sugar-cane in Samoa. There has been much confusion between this species and *P. boninsis*, Kuw., and it is impossible to say which is the species referred to.

Trionymus sacchari, Ckll. Swezey records this scale from sugar-cane in Samoa.

Ceroplastes rubens, Mask., was taken by us in several localities in Upolu on cinnamon, fern and other plants. Doane & Ferris obtained it in Samoa very abundantly on mango. Buxton obtained specimens on "niaouli" (*Melaleuca* sp.) at Tontouta, New Caledonia.

Pulvinaria psidii, Mask., is recorded from Samoa by Doane & Ferris. Buxton obtained specimens on lemon leaves at Vila, New Hebrides.

Eucalymnatus tessellatus, Sign., var. *perforatus*, Newst., occurred on cinnamon at Malua and on *Morinda citrifolia* at Apia; both localities are in Upolu.

Coccus acuminatus, Sign. We obtained this widely-distributed species on pine-apple at Apia, Upolu, and on a fern at Vila, New Hebrides.

Coccus hesperidis, L. Only obtained once by us, on leaves of mummy-apple (*Carica papaya*) at Apia.

Saissetia coffeae, Walk., occurred on *Morinda citrifolia* at Apia and on lemon at Vila. Coffee was formerly an important product in Samoa, but is no longer grown on a commercial scale.

Saissetia nigra, Nietn. We took this scale on several plants, including *Hibiscus rosa-sinensis*, at Apia, on Swain's Island, and at Tanna, New Hebrides.

Saissetia oleae, Bern., is recorded by Doane & Ferris as common on orange in Samoa.

Pinnaspis aspidistrae, Sign. Doane & Ferris record this species from palm, banana, and orange, in Samoa.

Pinnaspis minor, Mask., occurred commonly on coconut leaves in several islands of the Ellice Group, but did not appear to do much damage. It also occurred on banana in Swain's Island. We did not take it in Samoa, but it doubtless occurs there.

Chionaspis citri, Comst., is recorded by Doane & Ferris as very abundant on orange in Samoa.

Aspidiotus cydoniae, Comst., is recorded by Doane & Ferris on orange.

Aspidiotus destructor, Sign. Neither we nor any other collectors have obtained this species in Samoa, but Sasscer recorded it in California on coconuts from Tutuila, American Samoa. According to Simmonds it is very destructive in Fiji.

Aspidiotus pangoensis, Doane & Ferris, was described from material collected on coconut husks at Pago-Pago, Tutuila.

Aspidiotus (*Morganella*) *maskelli*, Ckll., is stated by Maskew (1916) to have been intercepted in quarantine in California on oranges from Samoa.

Chrysomphalus rossi, Mask. Swezey records this species on coconut in Samoa.

Chrysomphalus aonidum, L. Maskew (1920) records the presence of this species in California on coconuts from Tutuila.

Odonaspis secreta, Ckll., is recorded by Doane & Ferris on bamboo in Samoa.

Lepidosaphes beckii, Newm., *L. gloveri*, Pack., and *L. moorsi*, Doane & Ferris, all occur on orange in Samoa. *L. moorsi* was described from specimens collected near Apia.

Parlatoria cinerea, Doane & Hadden, is stated by Doane & Ferris to be common on orange in Samoa.

APHIDIDAE.

Toxoptera aurantii, Boyer. We obtained this species on leaves of cacao and of *Hibiscus tiliaceus* at Apia.

ISOPTERA.

Microcerotermes peraffinis, Silv. The mud-carton nests of this termite are common on the trunks of coconut palms and other trees (including mango) everywhere in the

lowlands of Samoa ; they are usually placed 4 to 8 feet up the trunk. The direct damage done to the tree seems to be very slight, but when the nest is deserted the galleries allow rain to enter the trunk, which then rots. In the islands of the Ellice Group *Calotermes rainbowi*, Hill, is a serious pest of coconuts; it tunnels in the otherwise undamaged trunks. A specimen of the damage done by it is shown on Plate ii, fig. 2.

Prorhinotermes inopinatus, Silv. A quantity of paper stored in a damp cupboard was destroyed by this species at Apia in May 1925.

Calotermes (*Cryptotermes*) *buxtoni*, Hill. Under this name Hill has described a colony of termites which destroyed a chair at the Apia hospital; the woodwork of the hospital car was also destroyed by termites, possibly this species, but unfortunately all the affected woodwork had been burnt before I was able to obtain specimens of the insects for identification.

Calotermes (*Neotermes*) *sarasini*, Holmgr., has been recorded by Demandt as a pest of cacao in Samoa. I have not been able to trace the synonymy of this species.

COLEOPTERA.

COCCINELLIDAE.

Coccinella transversalis, F., was common in gardens, where it destroyed Aphids on cucumbers and other plants.

Epilachna 28-*punctata*, F. A very common and serious pest of cucumber and allied plants ; all stages occurred on the plants and I also found both larvae and adults damaging egg-plant.

CLERIDAE.

Necrobia rufipes, De Geer. This wide-spread insect is quite the commonest pest of stored food in Samoa and is also abundant in Tonga and Fiji. The copra stores in Apia and elsewhere, the boats engaged in the transport of this material, and private houses in the neighbourhood of the wharf, all swarm with this insect, known locally as the " copra-bug." It is also common in dried fruit, such as currants and raisins.

DYNASTIDAE.

Oryctes rhinoceros, L. Since 1910, when it was introduced with *Hevea* plants from Ceylon, this has been by far the worst agricultural pest in Samoa. Copra is the main export of the country, and not only does the beetle damage and kill many coconut trees directly, but its burrows allow the entry of a fungus which is the cause of bud-rot in Samoa (the primary form of bud-rot is apparently absent). Friederichs records (1913, 2) that attempts to introduce moles and hedgehogs to deal with the beetle failed, and he regards infection of the larvae with the green Muscardine fungus (*Metarrhizium anisopliae*), coupled with the use of trap breeding-places, as the most hopeful method of control, but other workers do not report on it very favourably. It may well be that the Samoan form of fungus is a particularly virulent strain, for in the experiments carried out in Ceylon by Bryce and elsewhere by other workers the Samoan strain was not used ; it is difficult to explain the discrepancy between their results and those of Friederichs except on some such assumption. Pigs undoubtedly are of use against the beetle in Samoa ; it was noticeable that in the district near Fagamalo, Savaii, where many pigs are kept in the plantations, *Oryctes* damage was not very great, while in the Apia district it was much more obvious. This is in spite of the facts that the cultivation in the Apia district is much the cleaner of the two, and that, since it is near the capital, beetle-inspection in this district is likely to be somewhat stricter than in the out-district. There is little or no attempt to burn the heaps of rubbish regularly in the Fagamalo district.

The trap breeding-places and the use of *Metarrhizium* have now been entirely abandoned ; it was considered too expensive to keep the traps in use, and the fungus is of little value except where the larvae can be concentrated by some such means. Cultivation is fairly clean in the European plantations, particularly those belonging to the Administration, but much less satisfactory in some of those in native ownership ; in this respect Western Samoa is much in advance of Tutuila (American Samoa). The chief active measure against the beetle now in use is the systematic collection of the adults and early stages. Monday of each week is set apart as a beetle-collecting day for plantation labour and for the native population. Each Samoan adult male pays a tax of a certain number of beetles and larvae to the village chief, who sees that they are destroyed ; " beetle-inspectors " are employed by the Administration to inspect plantations and see that the regulations with regard to the beetle are carried out.

It is very unfortunate that no attempt has been made to introduce an *Oryctes*-eating *Scolia* such as *S. oryctophaga*, into Samoa ; this course was recommended by Friederichs in 1913, but nothing has ever been done in the matter. The reason given is that the present measures keep the insect in check and that the success of the introduction, if made, would not be assured. The present methods, however, though they prevent the damage becoming very extensive, do little beyond this, and can never seriously reduce the numbers of the beetle ; they are, besides, wasteful in the extreme, more particularly in the matter of labour. Furthermore there is always great danger of the beetle getting out of hand during any labour-shortage, as actually happened during the influenza epidemic in 1918. It is only fair to note, however, that the beetle-inspectors would not become wholly useless in the event of the successful establishment of a natural check on the beetle, as they act as travelling agents for the Administration in many other matters in the more remote districts.

RUTELIDAE.

Adoretus versutus, Har. (*A. vestitus*, Boh.). Very common throughout the year in the Apia neighbourhood. Friederichs (1914) records the adults as a pest of cacao and coffee ; the larvae eat grass roots and do little damage.

CERAMBYCIDAE.

Haplohammus ? coenosus, Kirby. A larva of this species tunnelled and killed a *Poinsettia* bush in my garden. When discovered it was nearly full-fed, and when transferred to a piece of rotten wood an adult appeared about five weeks later.

Demandt records *Monochamus rusticator*, F., as a pest of cacao.

CHRYSOMELIDAE.

Aulacophora similis, Oliv. Adults very common on cucumber and other Cucurbits, eating the flowers. This is presumably the species which Swezey found attacking the same plants and which he recorded as " *A. fabricii* ? "

Promecotheca reichei, Baly (*lindingeri*, Aulmann). Aulmann described his *P. lindingeri* from Samoa in 1914 and stated that it was a pest of coconut. He found both larvae and adults on the leaves and described the characteristic damage ; Swezey in 1923 found the larvae boring the leaves, but not common enough to do much damage. We found the species unexpectedly uncommon and had great difficulty in finding specimens ; it is certainly no longer a serious pest.

Metriona strigula, Montr. This species occurred in small numbers on sweet potato (*Ipomaea batatas*) on several occasions, but it was never common enough to be of any importance.

CURCULIONIDAE.

Rhabdocnemis obscura, Boisd. Swezey in 1923 found this insect as a pest of both sugar-cane and coconut. We did not find it very common.

Cosmopolites sordidus, Germ. Swezey found this species attacking bananas and suggested that it was then recently established. It is still by no means common and does little damage.

Elytroteinus subtruncatus, Fairm. Was found by Swezey breeding in sugar-cane.

Diocalandra taitensis, Guér. According to Swezey this weevil does considerable damage to coconut in Samoa.

SCOLYTIDAE.

Dacryphalus (*Cryphalus*) *mangiferae*, Stebb. We bred this species in some numbers from a mango-branch, unhealthy but not dead, in Apia, July 1924. It was recorded by Stebbing as attacking green shoots of the same tree in India.

LEPIDOPTERA.

NYMPHALIDAE.

Hipio leda solandra, F. Swezey records finding the larvae of this butterfly (which he calls *Melanitis leda*, L.) twice on sugar-cane. The insect is by no means common and the damage to sugar-cane done by it is quite negligible. The larva apparently feeds usually on wild grasses.

NOCTUIDAE.

Prodenia litura, F. The larvae of this species were found abundantly on taro with those of *Hippotion celerio* and apparently are only second to them as a pest of this crop. The young larvae feed quite exposed on the upper surface of the leaf and destroy the epidermis. I also found them mining into tomato-fruits in my garden, the affected fruits being very conspicuous, as they ripen prematurely ; the inside of the fruit is completely eaten out. Pupation occurs in the earth.

Othreis fullonica, L. This well-known fruit-pest was very common in the neighbourhood of Apia, the larvae feeding on *Erythrina* ; I also found the larvae at Pago-Pago, Tutuila Island. On several occasions we found the larvae being sucked by a small fly of the genus *Forcipomyia*.

Heliothis assulta, Guen. Edrozo records this insect as a tobacco-pest in Samoa, and there are specimens from this group in the British Museum, but it does not appear to be at all common.

Phytometra chalcites, Esper. The larvae were rather common in gardens from July to September 1924, eating the leaves of cucumber and tomato ; they are green and feed on the underside of the leaves.

SPHINGIDAE.

Hippotion celerio, L. This species (recorded as a pest of taro by Swezey in 1924) is quite the most important pest of this major food-crop in Samoa ; it also attacks ta'amu and garden varieties of Aroids. The larvae were found on many occasions on taro ; they often defoliate the plants completely and even eat holes in the leaf-stalks. They were particularly abundant in April, May and July, 1924, both at Apia and at an elevation of 2,000 feet at Malololelei. A specimen of the damage at this latter place is shown on Plate ii, fig. 1. In the Tokelau Group Buxton found the ta'amu on Atafu Island much damaged, apparently by these larvae, but he was not able to find any of them.

PYRALIDAE.

Corcyra cephalonica, Stn. Large numbers of the larvae were found infesting stored rice in Apia, in May 1924.

Nacoleia octasema, Meyr. A very serious pest of bananas in Samoa. The red-brown larvae make webs between the young bananas, high up in the spaces between the members of each "hand" and eat through the skin of the young fruit, which frequently dies as a result. In cases of less serious attack the banana ripens but is left scarred, often twisted, and undersized (fig. 1); the damage is generally worst in the more distal part of the bunch, and frequently the whole bunch is so damaged as to be quite useless. The pupa is formed in a web between the fruits. The species is also known from Fiji, where it does much damage, and from Queensland, Java and other countries. Swezey recorded it in Samoa in 1924.

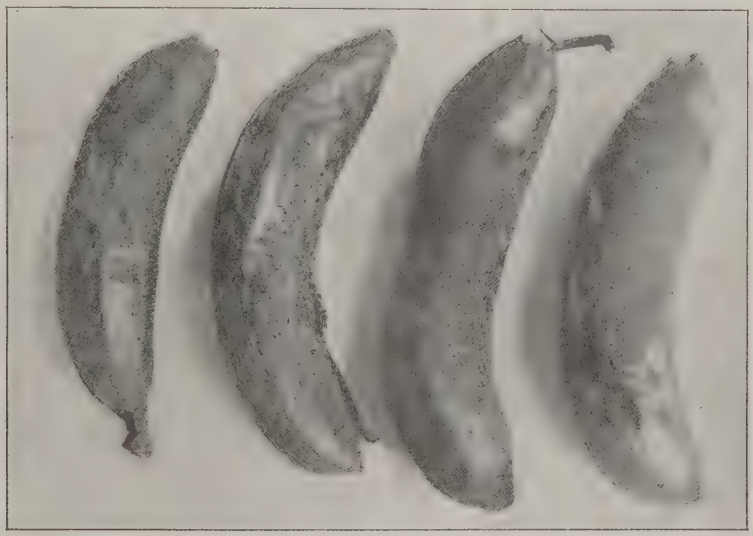

Fig. 1. Bananas attacked by caterpillars of *Nacoleia octasema*, Meyr.

Glyphodes indica, Saund. The larvae of this species (as recorded by Swezey) attack cucumber, eating the leaves. It does not seem to be very common in Samoa

Lamprosema diemenalis, Guen. Abundant in gardens, the larvae eating the leaves of beans, of which they are the worst pest in Samoa; they mine the upper epidermis and roll the leaf over to form a shelter. Specimens of an undetermined Chalcid were bred from the pupae.

Sylepta derogata, F. Larvae were found curling the leaves of *Hibiscus tiliaceus* in June 1924, at Apia.

Maruca testulalis, Hb. Beans in my garden were extensively damaged by the larvae of this species in June 1925. They did not appear to care for the leaves, but attacked the pods, the interior of which they ate out. The favourite point of attack was where two pods touched.

EUCOSMIDAE.

Crocidosema plebeiana, Zell., appears to be widely distributed in Samoa; we captured specimens in several localities in Upolu and Savaii; it is also recorded from Fiji and Tonga. The larva feeds on *Hibiscus* and other Malvaceae.

Polychrosis botrana, Schiff. Of this well-known vine-pest we obtained one specimen at Malololelei, Upolu Island, at an elevation of 2,000 feet, and another in the Ellice Islands. In neither locality is it of real importance, as vines are not grown on any extensive scale.

ELACHISTIDAE.

Cosmopteryx dulcivora, Meyr. Swezey recorded larvae found mining the mid-ribs of sugar-cane leaves in Upolu under this name. His determination was based solely on the similarity of the damage to that done by *C. dulcivora*, and as the species has never been recorded from Samoa and he obtained no adults the determination is extremely doubtful. We did not obtain it.

AGONOXENIDAE.

Agonoxena argaula, Meyr., the larvae of which attack the leaves of coconut, is recorded by Simmonds from Samoa among other localities. We obtained specimens at Apia and in the Ellice Islands; the type-locality is Fiji.

PLUTELLIDAE.

Plutella maculipennis, Curtis (*cruciferarum*, Z.). What appeared to be this species was abundant in June 1924 in cauliflowers at Malololelei. Unfortunately no specimens were preserved, so that the identification is uncertain.

HYPONOMEUTIDAE.

Prays citri, Mill., was common on *Citrus* at Malololelei. It is widely distributed in the tropics and subtropics, and is recorded from Fiji.

GELECHIIDAE.

Platyedra gossypiella, Saund. Larvae of this species were brought to me from an experimental cotton-crop in the Apia neighbourhood; we also took the adult in the Aleipata district of Upolu.

Phthorimaea heliopa, Low. Of this well-known tobacco-pest Meyrick says: "Rebel describes (from Samoa) as *Gelechia* (*Lita*) sp., without recognising or naming it, an insect which is unquestionably this species." We did not obtain specimens of it.

DIPTERA.

TRYPETIDAE.

Dacus (*Chaetodacus*) *xanthodes*, Broun. This is the common fruit-fly in Samoa; we bred it from several kinds of fruits including paw-paw, bread-fruit, passion-fruit, and tomato, the latter showing no external injury; Swezey bred it also from guava, granadillas, avocado pear, and native fruits. We captured or bred it in almost every month of the year. It is a common practice to score the rind of a paw-paw to hasten ripening; such fruits are very frequently attacked by this insect. The species was identified by Prof. M. Bezzi.

Ceratitis capitata, Wied., is apparently still absent from Samoa, but the short-sighted local policy of allowing the free importation of fresh fruit from Australia renders it merely a matter of time before it is introduced. The volume of this trade is so small that it could be abolished without causing any great hardship, and both the Agricultural Department and the Planters' Association are strongly in favour of this course, but the opposition to it of the local store-keepers is so strong that it has not yet been possible to carry it out.

ORTALIDAE.

Scholastes bimaculatus, Hendel, is, as suggested by Swezey, probably not a pest ; we found the larvae on many occasions in coconuts, but always on those which had been opened while unripe and had become rotten ; we also bred a single specimen from cow-dung. The larvae are apparently able to withstand partial starvation for a considerable time ; some found in a rotten coconut on 5.ii.1924 remained without pupating until the beginning of April ; they were then transferred to a fresh piece of coconut and pupated in a few days. Besides those from Upolu we have specimens from Savaii and Tutuila, and from Funafuti in the Ellice Group.

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Fig. 1. Taro plants (*Colocasia esculenta*) eaten by *Hippotion celerio*, L., Upolu Island, Samoa.

Fig. 2. Living coconut palm damaged by *Calotermes rainbowi*, Hill, Nanomaga Island, Ellice Group.

EIGHT NEW SPECIES OF BRACONIDAE.

By D. S. Wilkinson,
Senior Assistant, Imperial Bureau of Entomology.

Subfamily Vipiinae.

Microbracon kirkpatricki, sp. n.

♂♀. Pale reddish testaceous with the 1st and 2nd tergites often almost stramineous; antennae of a darker red; extreme apex of tarsi black; ovipositor sheaths dark brown to black; the male often with the 2nd–5th tergites discally brownish; ocelli black, the ocellar area sometimes darkened; legs, particularly the hind legs, often stramineous or nearly so; stigma and wing veins pale reddish, except that in the forewing the 1st abscissa of the anal vein and the basal half of the 1st abscissa of the medial vein are virtually colourless, and that the costal vein is brownish, and that the stigma in the males is brownish.

♀. Integument noticeably coriaceous throughout, except the appendages. *Head* broadly rounded behind, 1·75 times as broad as long; ocelli on a more or less distinct tubercle, not close together, the posterior ones only somewhat nearer to one another than to the eye; flagellum with 25–29 joints, the majority of specimens with 27–29 joints; apical joint of antennae wth a short apical style; head impunctate and narrowly coriaceous. *Thorax* impunctate, with mesonotum, scutellum, and propodeon, more broadly coriaceous than the head; mesopleurae more broadly coriaceous again; the lines of the notauli only faintly indicated, but noticeable, chiefly on account of the enclosed median area which is raised somewhat and which, tapering to a point, reaches almost to the scutellar depression; scutellar depression apparently sometimes weakly crenulate and sometimes plain; propodeon completely plain except for a median, very weak, longitudinal excavation extending about half the length of the propodeon, when it becomes a fairly well marked longitudinal carina which extends to apex, where it joins the transverse apical ridge. *Wings* (fig. 1) with

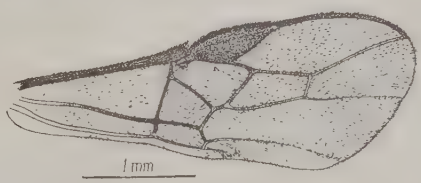

Fig. 1. *Microbracon kirkpatricki*, sp. n., wing.

a fenestra (apparently) at the junction of the 1st transverse cubital with the cubital; 2nd transverse cubital sometimes more or less obsolete. *Legs* with hind femora thickened somewhat and distinctly flattened. *Abdomen* generally about as broad as the combined lengths of the 3rd, 4th, 5th, and 6th segments; petiole (central area) somewhat longer than broad at apex, considerably shorter than basal breadth of 2nd segment; the petiole is rugose and has on each side a strongly impressed and often crenulate line running from the apical angles and meeting its fellow somewhat before the base of the segment; 2nd and 3rd tergites often more rugose than coriaceous and generally, but not always, faintly striate; 2nd tergite with a fairly strong median keel for almost its entire length, but often only on basal half; 2nd suture (suturiform articulation) (fig. 2) strongly bisinuate, crenulate; 4th and succeeding tergites mostly coriaceous and not or hardly rugose, and not striate; apical ventrite conspicuous, sometimes projecting somewhat beyond the apex of the tergites; ovipositor sheaths about as long as the abdomen, which is generally about 1·5 mm. long.

♂. Agrees with female except for the following :—Flagellum with 23–29 joints, but the greater number of specimens with 27 joints ; 2nd suture not strongly, only somewhat, sinuate medianly.

Length : ♀, 3–4 mm.; ♂, 2–3 mm., generally about 3 mm.

KENYA COLONY : 15♀♀, 6♂♂, Malindi, ii.1927 (*T. W. Kirkpatrick*-type). TANGANYIKA TERRITORY : 4♀♀, 6♂♂, Morogoro, 29.ix.1922, xi.1922, 4.xii.1922, 6.xi.1923, and 10.xi.1923 (*A. H. Ritchie*).

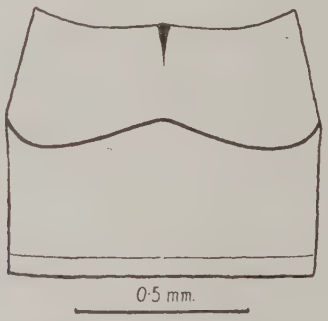

Fig. 2. *M. kirkpatricki*, sp. n., ♀, second abdominal suture.

Mr. Kirkpatrick states that he is breeding this parasite in quantities from *Platyedra gossypiella*, Saund., while the specimens received from Mr. Ritchie are labelled " Parasites of the Pink Bollworm."

Type deposited in the British Museum.

This species is very like *Microbracon lefroyi*, D. & G., but may be immediately separated from this latter, apart from other characters, by the ocelli, which in *M. lefroyi* are noticeably smaller and more remote from the eyes ; by the sinuosity of the second suture in the females, which in *M. kirkpatricki* is considerably stronger ; and by the colouration generally.

Subfamily DORYCTINAE.

Rhaconotus scirpophagae, sp. n.

♂♀. Dark red, tinged with black and blackish-red, head capsule tending to be rather paler ; all legs rather pale red-testaceous ; ovipositor bright red, black at extreme apex ; sheaths black ; the apical joint and often the pre-apical joint or joints of all tarsi darkened to nigrescent ; wings with tegulae and costal vein pale red-testaceous, remaining wing veins red-brown ; stigma very pale yellow to almost colourless ; wings hyaline except for a very slight general infuscation.

♀. All integument coriaceous and with strong pubescence. *Head* : antennae longer than head, thorax, and abdomen together ; flagellar joints about 40, but the number is variable. *Thorax* : notauli anteriorly strongly marked, posteriorly more or less obsolete ; scutellar depression broad but not deep, with at least a median longitudinal carina ; metathorax at least crenulate medianly ; propodeon with at least three longitudinal carinae at base, one in the middle, the others at the sides, these carinae extending almost half-way down the propodeon and becoming lost amongst the wrinkles with which the apical two-thirds of the propodeon abounds ; basal third of propodeon more or less devoid of wrinkles. *Wings* with the recurrent interstitial or received distinctly into the 2nd cubital ; nervulus interstitial or very slightly postfurcal ; radial cell reaching apex of wing ; stigma sub-lanceolate ; 2nd

abscissa of radial vein three times, and 3rd abscissa five times, as long as 1st abscissa ; 2nd abscissa in the neighbourhood of 0·495 mm. long ; radial emitted from about the middle of the stigma ; 2nd cubital cross-vein very faint. *Legs* : front femur usually 0·6 mm. long with a noticeable tumescence on the antero-dorsal surface at apex of basal third ; front tibia usually 0·6 mm. long, and on its anterior surface a row of generally eight small stout spines commencing at about the apex of the basal third and

Fig. 3. *Rhaconotus scirpophagae*, sp. n., abdomen.

extending to about the base of the apical fourth ; front tarsus usually about 0·96 mm. long ; middle femur usually 0·6 mm., with a noticeable tumescence on the antero-dorsal surface at apex of basal third ; middle tibia 0·65 mm. long, and on its antero-dorsal surface a row of generally five small stout spines, usually four of them evenly spaced and placed towards the apex of basal half of tibia, the fifth somewhat isolated at about base of the apical third, but the number of spines may vary from four to six and their position is somewhat inconstant ; middle tarsus 0·66 mm. long ; hind coxa about 0·38 mm. long, with a small, fairly sharp prominence (blunted tooth) towards base of ventral surface ; hind femur 0·68–0·75 mm. long, with a tumescence on the antero-dorsal surface at apex of basal third ; hind tibia 1·05–1·2 mm. long, devoid of spines ; hind tarsus 1·2 mm. long ; the 3rd and 4th joints of all tarsi the smallest, the 5th joint being definitely longer than the 3rd ; basal joint of hind tarsi as long as, or shorter than, 2nd and 3rd joints together. *Abdomen* (fig. 3) with the four basal tergites nearly completely longitudinally carinate ; 5th tergite only carinate basally and with basal half noticeably more strongly coriaceous than apical half ; 1st suture plain, 2nd, 3rd, and 4th sutures strongly crenulate ; 1st tergite longer than broad ; 2nd tergite transverse ; 2nd suture, which is more or less obsolete laterally, strongly curved ; 3rd and 4th tergites transverse and noticeably shorter than the 5th tergite, which is also transverse ; 3rd and 4th sutures straight ; ovipositor long, extending at least 1·5 mm. beyond apex of abdomen, which length is less than the combined lengths of the 2nd, 3rd, 4th, and 5th tergites.

♂. The description for the female applies equally for the male, except for the following:—*Head*: antennae with a smaller number of joints. *Wings* with the recurrent received only into the 2nd cubital cell. *Legs*: front femur and tibia 0·54–0·6 mm. long; front tarsus 0·83–0·87 mm. long; middle femur 0·51–0·57 mm.; middle tibia and tarsus 0·6–0·68 mm.; hind femur 0·6–0·72 mm.; hind tibia 0·9–1·13 mm.; hind tarsus 1·05 –1·11 mm.; hind femora without tumescence. *Abdomen* with 5th tergite generally (more seldom only basal half) as completely carinate as the basal segments, and the more strongly coriaceous condition invariably extending almost to apex; 2nd suture not strongly curved, almost straight; 3rd and 4th tergites not noticeably shorter than the 5th.

Length: ♀, about 4·5–5 mm.; ♂, about 4·25–4·5 mm.

India: 14♀♀, 7♂♂, Pusa, Bihar, 9–31.iii.1914, 10.viii.1915, 23.iii.1916, and 22.xi.1916.

Received from the Imperial Entomologist and recorded as a parasite of a Pyralid moth, *Scirpophaga auriflua*, in sugar-cane.

Type deposited in the British Museum.

Variation is very noticeable in the extent of the carination of the 5th abdominal tergite, together with the extent of its more strongly coriaceous portion. The colour of the head is also very variable, being either comparable with that of the legs or with that of the thorax. Considerable variation is noticeable both in this and in the following species in the relative lengths of the legs, such variations being in no wise dependent upon the size of the individual, apart from the differences in the sexes; no specific value can be attached therefore to the measurements presented.

After the foregoing description had been written for this species I found amongst the large mass of material awaiting identification two specimens of a *Rhaconotus* that had been received by the Bureau from the Tanganyika Territory (*A. H. Ritchie*), labelled "12.viii.1925, rice stem." I am unable to differentiate between these and *R. scirpophagae* except that the former are somewhat lighter in colour possibly, and that they have the 1st abscissa of the cubital more strongly sinuate, characters both subject to great variation. *R. scirpophagae* must, therefore, in addition be recorded from Africa.

Rhaconotus sudanensis, sp.n.

♀. A rich dark red often tinged with black and with large portions often completely black; head and basal two-thirds of flagellum of a decidedly paler red, nearly but not so pale as the legs, which are rather pale reddish-testaceous, with the apical joints of tarsi darkened; scape of antennae darker than base of flagellum; about apical 14–16 joints of antennae nigrescent to black; ocelli in a dark spot; ovipositor bright red; sheaths black; wing veins mostly light brown; stigma discally light brown, narrowly at apex and broadly at base pale to almost colourless, much the same colour as the parastigma, costal vein and tegulae; wings hyaline.

♀. All integument coriaceous and mostly with fairly strong pubescence. *Head*: antennae just longer than head, thorax, and abdomen together; flagellar joints 28–32. *Thorax*: notauli anteriorly strongly marked, posteriorly converging into a median definitely somewhat sunken area; scutellar depression broad but not deep, crenulate, having about four or five longitudinal carinae; metathorax crenulate medianly and in some specimens apparently also weakly crenulate laterally; propodeon generally but not invariably with three longitudinal carinae, one in the middle, the others at the sides, the former sometimes extending half-way down the propodeon, the latter considerably shorter, all becoming lost amongst the wrinkles with which the apical half of the propodeon abounds; propodeon basally either more

or less devoid of wrinkles or with some weakish wrinkles running longitudinally. *Wings* with the recurrent interstitial or just received into the 2nd cubital cell ; nervulus postfurcal by almost its own length ; radial cell reaching apex of wing ; stigma sublanceolate ; 2nd abscissa of radial vein about four and a half times, and 3rd abscissa about six and a half times, as long as the 1st abscissa ; 2nd abscissa about 0·405 mm. long ; radial emitted from about middle of stigma ; 2nd cubital cross-vein very faint. *Legs* : front femur 0·47–0·51 mm. long, with a noticeable tumescence on the antero-dorsal surface at apex of basal third, as have all the femora ; front tibia generally about 0·51 mm. long, usually with a row of small stout spines arranged apparently in the same manner as in *R. scirpophagae*, but these spines are not easily distinguishable and are apparently absent in some specimens ; front tarsus 0·74–0·81 mm. long ; middle femur 0·45–0·54 mm. long ; middle tibia 0·54–0·57 mm. long, with a row of small stout spines arranged in apparently the same manner as in *R. scirpophagae*, except that they are not so easily to be distinguished and are apparently altogether absent in some specimens ; middle tarsus 0·54–0·6 mm. long ; hind coxa about 0·32 mm. long, with ventral basal prominence as in *R. scirpophagae* ; hind femur 0·6 mm. long ; hind tibia 0·9–1·05 mm. long, apparently devoid of spines ; hind tarsus 0·87–0·96 mm. long ; the 4th joint of all tarsi is the smallest, the somewhat elongate apical joint not, or not definitely, longer than the 3rd ; basal joint of hind tarsus as long as, or longer than, the 2nd and 3rd joints together. *Abdomen* with the four basal tergites nearly completely longitudinally carinate, much as in *R. scirpophagae*, except that the carinae are weaker and somewhat more irregular, giving in certain lights, especially on the 1st and 2nd segments, merely a rugose appearance ; 5th tergite carinate only in basal third, except in one specimen which is carinate at least to apex of basal two-thirds ; 1st suture plain ; 2nd, 3rd, and 4th sutures crenulate ; 1st tergite longer than broad ; 2nd tergite transverse ; 2nd suture, which is more or less obsolete laterally, curved much as in *R. scirpophagae* ; 3rd and 4th tergites transverse and noticeably shorter than the 5th, which is also transverse ; 3rd and 4th sutures more or less straight ; ovipositor long, extending beyond apex of abdomen at least 1·5 mm., which length is greater than the combined lengths of the 2nd, 3rd, 4th and 5th tergites.

Length, 3·5–4 mm.

British Sudan : 5♀♀, Khartoum, 2.xi.1924, 8.xi.1924, and 2.xii.1924(*H. B. Johnston*).

Reported by Mr. Johnston as having been bred from cotton stems containing a Buprestid Beetle, *Sphenoptera gossypii*, Cotes.

Type deposited in the British Museum.

Key to Species of Rhaconotus.

1. Second suture straight ; antennae never of a uniform colour throughout ; wings with brown patches of infuscation ; stigma always in some part dark ... ... 2.

   Second suture curved (♀) ; antennae sometimes of uniform colour throughout ; wings either completely hyaline or faintly, more or less evenly, infuscated throughout ; stigma either very pale throughout or discally light brown, basally and apically pale ... 4.

2. Radial cell not reaching apex of wing ; wings brown with hyaline patches ; stigma black, basally white ; antennae yellow-red, apically black. Length 5 mm. African ... *spathulus*, Szép.

   Radial cell reaching apex of wing ; antennae red with at least basal four joints pale ... ... 3.

3. Antennae with basal four to five joints pale ; wings mostly hyaline, with some brown patches ; stigma apically brown, basally pale. Length 3 mm. European ... ... *aciculatus*, Ruthé.

Antennae with basal half pale ; wings infuscated from "mediodiscoidal" to apex ; stigma dark. Length 2·5 mm. Russian *scaber*, Koku.

4. Flagellum dark red throughout ; wings evenly very faintly infuscated ; stigma pale throughout ; flagellar joints 40 ; 2nd abscissa of radial 3 times, 3rd 5 times, as long as 1st abscissa ; ovipositor shorter than 2nd, 3rd, 4th, and 5th tergites together. Length 4·25–5 mm. Indian and African ... ... *scirpophagae*, sp. n.

Flagellum with apical 14–16 joints nigrescent ; wings hyaline, not at all infuscated ; stigma discally light brown, basally and apically pale ; flagellar joints 28–32 ; 2nd abscissa of radial 4½ times, 3rd 6½ times, as long as 1st abscissa ; ovipositor longer than 2nd, 3rd, 4th, and 5th tergites together. Length 3·5–4 mm. African (British Sudan) ... ... *sudanensis*, sp. n.

Previous writers on this genus seem to have assumed that the abdominal transverse crenulate furrows are the sutures, but, at least in these two new species, it is obvious that the crenulate furrows in the above descriptions referred to as the 3rd and 4th sutures are not in fact situate along the true line of the suturing ; it appears that the 3rd and 4th tergites are apically somewhat superimposed on the 4th and 5th respectively, so that when the abdomen is not bent the apical margins of the 3rd and 4th lie almost exactly over the crenulate furrows of the 4th and 5th ; when the abdomen is bent however a considerable area, more or less smooth, is visible medianly on these latter tergites anterior to their crenulated furrows.

Subfamily Opiinae.

Opius agreutretae, sp. n.

♂♀. Raw sienna ; vertex somewhat darker ; antennae, antennal setae, and apex of mandibles, black ; ocelli in a black spot ; costal vein of forewing, basal half of sub-costal of hindwing, and hind tarsi, dark brown approaching black ; setae of hind tarsi raw sienna ; ovipositor sheaths dark ; stigma basally and discally dark brown, more often noticeably paler apically ; in the forewing the 1st and 2nd abscissae of the medial vein, the lower half of the basal vein, and the nervulus, raw sienna ;* the upper half of the basal vein, the 3rd abscissa of the medial, and the nervus parallelus, brown ; the remainder of the nervures pale ; in the hind wing the medial, the cubital, and the basal veins, the nervellus, and the anal vein, are raw sienna ;* forewings in the apical half strongly and evenly setiferous and slightly infuscated ; in the 1st cubital cell, 1st discoidal, 1st brachial, and 2nd basal cells, the setae are weak and there is no infuscation ; the upper half of the 1st basal is more strongly infuscated than the apical half of the wing ; the hind wing is weakly infuscated apically, hyaline discally, and, like the forewing, more strongly setiferous and infuscated in the 1st basal cell.

♀. *Head* polished and shining, nearly twice as broad as long; breadth 0·87–1·14 mm., with an average of about 1·05 mm.; length 0·48–0·65 mm., with an average of about 0·59 mm.; face (fig. 4) with some strong punctures, and with a fairly broad raised median area which, extending upwards, becomes gradually narrowed and terminates as a sharp keel between the toruli ; facial depressions somewhat further

* In mounted wings this raw sienna colouration is intensified and appears as a light yellow, and as such is easily seen : the raw sienna colouration of these veins in dried specimens is not very apparent.

from one another than from the eyes ; clypeus evenly concave ; occiput strongly margined at sides from the oral region nearly to the level of the top of the eyes ; antennae longer than head, thorax, and abdomen, together ; flagellum with 40–46 joints, but the majority of specimens with 44 joints ; vertex impunctate ; cheeks somewhat punctate below. *Thorax* 1·5–1·88 mm. long, shining and virtually impunctate ; notauli only present as an anterior punctiform impression on each side ; mesopleurae above generally with a few weak punctures ; the mesopleural sulcus in the form of an elongate, fairly broad but weakly impressed depression, with about 8–12 strong, somewhat irregularly spaced and placed punctures in a row along the bottom of the depression, these punctures often being weak or obsolete anteriorly ;

Fig. 4. *Opius agreutretae*, sp. n., face.

scutellar depression crenulate, with about 11 carinae, the middle one being often somewhat the strongest ; scutellum transverse, apically above with a short, transverse, not easily distinguishable carina or ridge, above completely bare but around the sides and apically with a strong horizontal fringe of setae. *Propodeon* with two sinuate median longitudinal carinae enclosing a more or less wrinkled field from which exteriorly on each side there run five or six fairly short transverse carinae, which run into and terminate in a reticulate-wrinkled area ; the extreme sides of the propodeon are smooth with a few strong punctures. *Wings* with neuration as shown in figure 5 ; length of forewing generally about 4·5 mm., with breadth about 2 mm. *Legs* variable

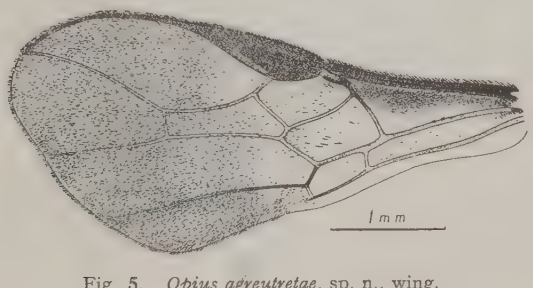

Fig. 5. *Opius agreutretae*, sp. n., wing.

in length but invariably with the front tarsus longer than the front tibia, and with the hind tarsus shorter than the hind tibia ; front femur 0·63–0·83 mm. long, averaging 0·74 ; front tibia 0·63–0·9 mm., averaging 0·82 ; front tarsus 0·81–1·05 mm., averaging 0·96 ; middle femur 0·69–0·9 mm., averaging 0·8 ; middle tibia 0·75–1·05 mm., averaging 0·91 ; middle tarsus 0·75–0·9 mm., averaging 0·89 ; hind femur 0·78–1·05 mm., averaging 0·95 ; hind tibia 1·05–1·47 mm., averaging 1·31 ; hind tarsus 1·02–1·35 mm., averaging 1·06. *Abdomen* about 1·95–2·63 mm. long, polished and shining, except that the petiole is roughened or wrinkled or wrinkled-reticulate and exhibits in each lateral half a strong longitudinal carina, which apically often breaks up into

longitudinal wrinkles, and except that the basal half of the 2nd segment is finely aciculate ; petiole about as broad at apex as long down the middle, but variable, varying from nearly $2\frac{1}{2}$ times to nearly twice as broad at apex as at base ; last ventrite elongated and projecting slightly beyond apex of tergites ; ovipositor sheaths about equal to length of thorax ; extension of ovipositor beyond apex of abdomen about equal in length to or possibly rather less than the distance from apex of 2nd segment to apex of abdomen, which distance is less than length of thorax.

♂. Agrees with the female except that it is a little smaller than in all the above measurements of the female (♂ abdomen 1·58–2·4 mm., breadth of head 0·77–1·05 mm., averaging 0·94 mm.)., and except that the 2nd abdominal segment is more or less completely devoid of aciculations.

South Africa : East London (*H. K. Munro*).

Described from 19♀♀ and 5♂♂ (including the type) bred in v.1923 from pupae of a Trypetid fly, *Agreutreta discoidalis*, Bez., from 1♀ bred from *Agreutreta bipunctata*, Lw., and from 3♀♀ and 1♂ bred from *Acanthiophilus muiri*, Bez.

Type deposited in the British Museum.

Of those species of *Opius* which receive the recurrent into the 2nd cubital cell *O. agreutretae* would seem to be most closely related to *O. inconsuetus*, Silv. This latter, however, differs in being a smaller and darker species with its propodeon smooth save only for the median longitudinal carina, quite apart from other good morphological characters.

Opius phaeostigma, sp. n.

♂♀. Ochraceous ferruginous ; flagellum, ovipositor sheaths, and hind tarsi brown ; dorsum of abdomen somewhat brownish ; ocelli in a black spot ; apex of mandibles black ; scape apically with some brown, or at least somewhat darker than at base ; forewings with at least basal two-thirds of the 1st abscissae of both the medial and the anal veins ochraceous to yellowish, remaining veins and stigma brown, with the costal vein a darker brown ; hind wings with the veins brown and the subcostal vein darker, except that the medial vein and almost the whole of the nervellus approach ochraceous.

Fig. 6. *Opius phaeostigma*, sp. n., face.

♂♀. *Head* polished and shining, nearly twice as broad as long, breadth 0·9–1·05 mm. ; length 0.48–0·53 mm. ; face (fig. 6) with some strong punctures, and with a broad raised median area which, extending upwards, becomes gradually narrowed, but does not terminate in a definite sharp keel, but becomes merged into a general raised area on which the toruli are situate ; immediately between the toruli the head has the appearance of having a sharply excavated V-shaped area, which condition is due solely to the general raised median area bifurcating at this point ; facial depressions nearly four times further from one another than from the eyes ;

clypeus virtually straight ; occiput strongly margined at sides from the oral region nearly to the level of the top of the eyes ; antennae longer than the head, thorax, and abdomen, together ; flagellum with 45 joints ;* vertex, occiput, and cheeks impunctate. *Thorax* 1·35–1·41 mm., polished, shining, and virtually impunctate ; notauli present only as a broadly impressed, anterior, almost punctiform depression on each side ; mesopleurae above with a few weak punctures ; the mesopleural sulcus as in *O. agreutretae* ; scutellar depression crenulate, with about 5–7 carinae, the middle one being somewhat the strongest ; scutellum transverse, bare above and without the strong apical fringe of setae round the sides or apex. *Propodeon* with a median longitudinal carina and somewhat roughened down each side of it ; towards the sides there are one or two short, oblique, more or less crenulate sulci ; otherwise the propodeon is smooth, shining, and impunctate. *Wings* (fig. 7) about

Fig. 7. *Opius phaeostigma*, sp. n., wing.

4·3 mm. long by 1·8 mm. broad. *Legs* with the front tarsus elongate, the basal joint being as long as, or longer than, the 2nd and 3rd joints together ; front femur 0·63–0·75 mm., averaging 0·68 ; front tibia 0·75–0·9 mm., averaging 0·83 ; front tarsus 0·9–1·05 mm., averaging 0·97 ; middle femur 0·69–0·84 mm., averaging 0·74 ; middle tibia 0·9–0·98 mm., averaging 0·92 ; middle tarsus 0·75–0·9 mm., averaging 0·85 ; hind femur 0·75–0·9 mm., averaging 0·82 ; hind tibia 1·2–1·35 mm., averaging 1·25 ; hind tarsus 1·2 mm. *Abdomen* about 1·8–1·95 mm. long, polished, shining, and smooth, except that the petiole is somewhat wrinkled in the apical half and bears two straight longitudinal carinae which are nearer to each other at their apices than they are basally, and except that the dorsum of the remaining segments is evenly but sparsely setiferous ; petiole about one-sixth longer down the middle than broad at apex, and about twice as broad at apex as at base ; apical ventrite conspicuous and extending just beyond apex of the tergites ; extension of ovipositor 2·31 mm. beyond apex of tergites.

Natal : Durban, xi.1922.

1 ♀ (type), 1 ♂, and 1 other of unknown sex. Bred from Dipterous, probably Trypetid, pupae.

Type deposited in the British Museum.

This species is extremely like *O. perproximus*, Silv., but may be easily separated as follows :— *O. phaeostigma* has the mesopleural sulcus considerably more elongate and not so broadly impressed ; it has the recurrent virtually interstitial, whereas in *O. perproximus* it is definitely received into the 1st cubital cell ; *O. phaeostigma* has the stigma brown, or at least mainly brown, while in *O. perproximus* it is mainly tawny ; and, lastly, while the length of the ovipositor in the latter species is 3·5 mm. as against 2·3 mm., the anterior wings are decidedly longer in *O. phaeostigma*.

* In two specimens the flagellum is broken.

Opius cosyrae, sp. n.

Extremely like *O. phaeostigma* and differing apparently from this species only in the following :—Hind tarsi not so dark a brown as the flagellum and ovipositor sheaths, which are dark brown to black ; vertex and cheeks with some weak punctures ; propodeon with a median longitudinal carina, which bifurcates about half-way down ; propodeon otherwise more or less roughened and only with some short, ill-defined, weakly crenulate, weak sulci, and with some punctures ; wings (fig. 8) about 3·7 mm. long by 1·5 mm. broad ; the longitudinal carinae of the petiole more parallel ; extension of ovipositor nearly 3·0 mm. beyond apex of tergites.

Tanganyika Territory : 2♀♀, Morogoro, 7.vi.1925 (*A. H. Ritchie*).

Mr. Ritchie states that these insects were parasitising a species of Trypetid, *Ceratitis* (*Pardalaspis*) *cosyra*, Wlk.

Type deposited in British Museum.

O. cosyrae also is easily separable from *O. perproximus* by the differences in the colouration of the stigma and the length of the ovipositor.

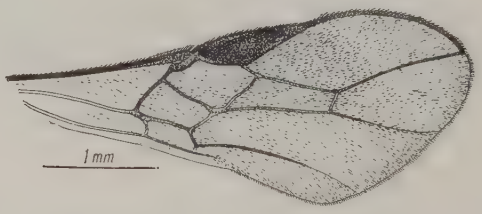

Fig. 8. *Opius cosyrae*, sp. n., wing.

The differences in the relative lengths (in mm.) of the various parts in these three closely allied species of *Opius* may be more conveniently seen in the accompanying table :—

	Body.	Ovipositor.	Forewing length.	Forewing breadth.
perproximus ...	3·0–3·5	3·5	3·6	1·6
phaeostigma ...	3·6–3·8	2·3	4·3	1·8
cosyrae	3·6–3·8	3·0	3·7	1·5

The determination of the foregoing species of *Opius* has only been rendered possible through the kindness of Professor Silvestri, who most courteously lent me cotypes of several of his African species and who has also presented some of them to the British Museum.

Subfamily Meteorinae.

Meteorus margaroniae, sp. n.

♂♀. Head (except for a large black area extending backwards from the toruli over the vertex and including the ocellar region and the greater part of the occiput), thorax, and ovipositor, red ; a blotch on each side at the base of the postpetiole, the 2nd abdominal segment mostly, and the 3rd, 4th, and 5th segments, shining brown ; hind coxae, hind femora, hind tibiae (except for the basal sixth which is whitish), and hind tarsi, a dullish fairly dark reddish-brown, except that the hind tibiae and tarsi in one or two specimens are definitely lighter in colour than the hind femora ; scape pale red ; flagellum brown ; palpi, all trochanters, the four anterior trochantines, petiole, and small basal portion of 2nd abdominal segment in the females, and in the

males the median apical portion also somewhat, white to dirty white ; all legs with a bright red annulus between femora and trochantines ; tegulae, the four anterior coxae, the four anterior femora together with their tibiae and tarsi, a pale indeterminate reddish-brown ; the 5th tarsal joint of each leg noticeably darker than the basal joints ; stigma and wing veins red-brown ; wings hyaline.

♂♀. *Head* transverse ; clypeus and face lightly and sparsely punctate ; in the males, face below just a little broader than clypeus, above definitely broader ; in the females, clypeus as broad as face ; flagellum with 31 to 32 joints, the apical joint drawn out to a point. *Thorax* with pronotum mostly wrinkled, but smooth above at the

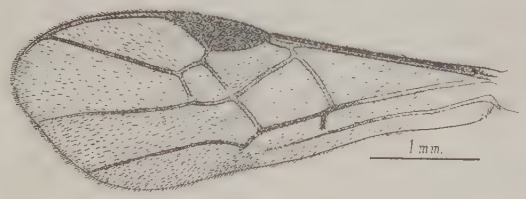

Fig. 9. *Meteorus margaroniae*, sp. n., wing.

sides ; mesonotum with the parapsides fairly closely but weakly punctate ; the notauli well-marked, broad, and wrinkled, converging posteriorly on a broad, slightly sunken, wrinkled, median area ; the anterior median portion of the mesonotum punctate, like the parapsides, and with a median keel running longitudinally from the anterior margin backwards, being traceable even in the wrinkled area ; mesopleurae punctate above, wrinkled below ; scutellar depression wide, with five or six weak longitudinal carinae ; scutellum punctate ; propodeon wrinkled-reticulate, without major carination, posteriorly somewhat concave in middle. *Wings* (fig. 9) with the 2nd abscissa of the radial at least 1½ times as long as the 1st abscissa, particularly in the females in

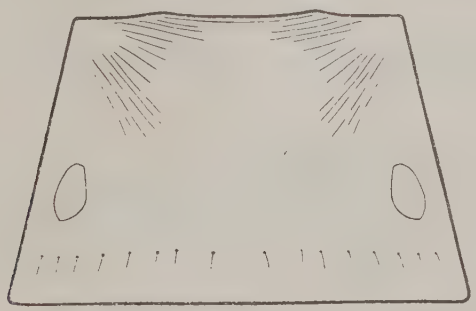

Fig. 10. *Meteorus margaroniae*, sp. n., second abdominal tergite.

which it approaches twice as long ; 2nd cubital cross-vein longer than the 2nd abscissa of the radial. *Legs*, particularly hind coxae and hind femora, mostly punctate. *Abdomen* : petiole about 2½ times as long as its extreme apical width, completely longitudinally striate, towards the apex the striations of each side at and near the middle tending to converge towards the middle and terminate, their places being taken apically by the pair next outside ; the apical width of the petiole ranges between 0·57 and 0·63 mm. for the females, and in the two males is 0·54 mm. ; the 2nd abdominal segment (fig. 10) varies between the extremes of 0·84 and 0·9 mm. wide at apex

and 0·53 and 0·56 mm. long down the middle for the females, the corresponding figures for the males being 0·75–0·78 mm. and 0·48–0·51 mm.; the dorsum of this segment entirely smooth, shining, and devoid of pubescence, except for some short, weak but definite, oblique striations or aciculations on each side towards, and radiating fanwise from, but not reaching, the basal angles of the segment, with a few such aciculations running transversely across the base of the segment in the middle, but these latter are very often absent, and the former also vary considerably in quality, in some forms being nearly obsolete, and in one male being, together with the transverse basal aciculations, entirely absent; there also occurs on the 2nd segment a transverse row of about 20 weak punctures running completely across the apical fourth of the dorsum; 2nd suture hardly determinable; 3rd segment 0·45 mm. long down the middle in the females, and 0·41 mm. in the males, entirely smooth and shining except for a transverse row of punctures similar to that on the 2nd segment; 4th and 5th segments as the 3rd except for length.

Length, approximately 5–6 mm. Ovipositor at least 2·7 mm.

South Africa: East London, ii.1923 (*H. K. Munro*).

Described from 4♀♀ and 2♂♂ bred from the larva of a Pyralid moth, *Margaronia dimorpha*, Janse.

Type deposited in the British Museum.

Meteorus komensis, sp. n.

♀. Black; head (except ocellar region and occiput), pro-, meso-, and metapleurae, tegulae, scutellum, all legs (except hind tibiae and hind tarsi which are nigrescent), and the ovipositor, red testaceous; scape red-brown; flagellum nigrescent; palpi stramineous; stigma and wing veins brown, except costal vein which is black; wings hyaline.

♀. *Head* transverse; clypeus and face slightly roughened; face broader than clypeus; flagellum with 30 joints, the apical joint pointed. *Thorax* with the parapsides faintly punctate; the notauli are present as fairly wide but shallow roughened lines converging posteriorly on a broad, slightly sunken, roughened median area; the anterior median portion of the mesonotum somewhat more punctate than the parapsides, without a well-marked, longitudinal, median keel, or only with trace of such a

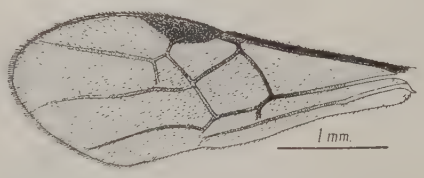

Fig. 11. *Meteorus komensis*, sp. n., wing.

keel; immediately beneath the tegulae the mesopleurae are roughened, towards the middle they are faintly punctate, and roughened again below; scutellar depression broad and deep, with some fairly strong longitudinal carinae; propodeon varying from roughened to wrinkled-reticulate, without major carination, posteriorly concave in the middle. *Wings* (fig. 11) with the 1st and 2nd abscissae of the radial of equal length; 2nd cubital cross-vein longer than the 2nd abscissa of the radial. *Legs* with the hind coxae very faintly punctate. *Abdomen*: petiole about twice as long as its extreme apical width, which is 0·39–0·42 mm., completely longitudinally striate,

the striations more or less straight and parallel ; the dorsum of the 2nd segment completely smooth, polished, shining, and devoid of pubescence except that in one or two specimens faint traces are visible of a transverse row of punctures in the apical fourth ; the 2nd segment averaging 0·6 mm. wide at apex and about 0·33 mm. long, the 3rd segment being about 0·36 mm. long, but the 2nd suture extremely fine and its exact position hard to determine ; 3rd segment as for 2nd, except that the transverse row of the exceedingly fine punctures in the apical fourth seems to be more regularly present ; 4th and succeeding segments as for 3rd except for length.

Length, approximately 3·5 mm. Ovipositor 1·2–1·5 mm. long.

Uganda : 6♀♀, Kome Isle, Lake Victoria, 6.v.1914 (*Dr. G. D. H. Carpenter*).

Type and cotypes in the British Museum.

From *M. margaroniae* and *M. komensis* the species of *Meteorus* previously described from Africa may be separated as follows :—

M. testaceus, Szép., is recognisable by the relative length of the 2nd abscissa of the radial to the 2nd cubital cross-vein ; *M. kleini*, Szép., has the meso- and metathorax, propodeon, and petiole black, with the remainder of the abdominal segments yellow, while *M. flavicornis*, Szép., has its legs, petiole, and 2nd segment white ; the petiole of *M. tricolor*, Szép., is also white, the tibiae and tarsi of the front and middle legs being whitish in front, with the stigma and wing veins black ; *M. capensis*, Cam., is easily distinguishable, having its head, thorax, and abdomen completely black ; *M. trilineatus*, Cam., has its face broader than the clypeus, and is without the posterior concavity of the propodeon so marked in *M. komensis* ; *M. laphygmarum*, Brues, *M. neavei*, Brues, and *M. fasciatus*, Brues, are species mainly yellow in colour ; finally, *M. durbanensis*, Brues, may be separated from *M. komensis* by the character of the clypeus, and from *M. margaroniae* by many characters, notably those of the mesonotum, notauli, and hind coxae.

Wing Terminology.

The terminology that has been used above in the descriptions of the parts of the wings is fully set out below ; moreover, I propose to utilise this terminology in all subsequent work on the Braconidae, or until such time as a better or more complete system is evolved.

It will be admitted that, of late years, a large number of different systems of terminology for the veins and cells of the Braconidae have sprung into being, to such an extent, indeed, that recourse is nearly always necessary to the explanatory diagrams published by the author that one is reading. These diagrams, however, are almost invariably incomplete, or with the limitations of the parts ill-defined, so that much confusion arises.

I make no claim that the system I have adopted is original—with the possible exception of the clearness with which it is presented—or that the terms and groupings are morphologically correct ; in fact endeavour has been made to agree, so far as possible, with the more usually accepted terminology of reputed authorities—with due regard to our increased knowledge of the morphological significance of the various parts—in order to avoid launching yet another new system, and to this end I sought and obtained the kind and invaluable assistance of Dr. J. Waterston, of the British Museum, and of Dr. Ch. Ferrière, who has just lately accepted an appointment in the Imperial Bureau of Entomology. I understand, further, that both these gentlemen propose to adopt this system.

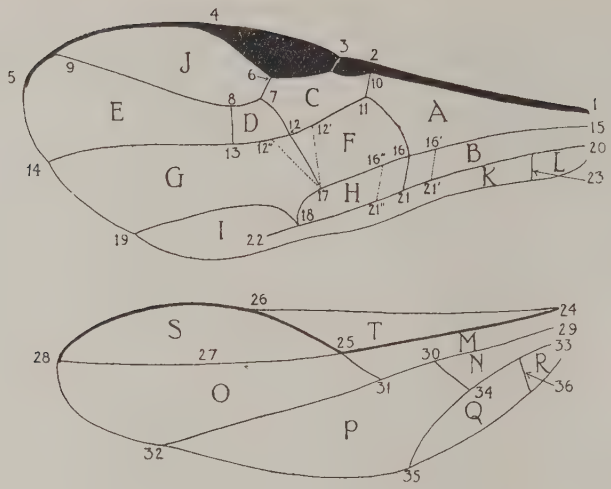

Fig. 12. Schematic diagram of a Braconid wing.

Explanation of Diagram.

Forewing. Veins.		Forewing. Cells.		Hindwing. Veins.		Hindwing. Cells.	
1–2	Costal	A	1st Basal	24–26	Costal	M	1st Basal
2–3	Parastigma	B	2nd Basal	24–25–26	Subcostal	N	2nd Basal
3–4	Stigma	C	1st Cubital	26–28	Metacarp	O	Cubital
4–5	Metacarp	D	2nd Cubital	25–27–28	Radial	P	Discoidal
6–9	Radial	E	3rd Cubital	29–31	Medial	Q	Anal
6–7	1st abscissa	F	1st Discoidal	29–30	1st abscissa	R	Axillary
7–8	2nd abscissa of	G	2nd Discoidal	30–31	2nd of medial	S	Radial
8–9	3rd radial	H	1st Brachial	31–32	Cubital	T	Costal
11–14	Cubital	I	2nd Brachial	31–25	Basal		
11–12	1st abscissa	J	Radial	33–35	Anal		
12–13	2nd of	K	Anal	33–34	1st abscissa		
13–14	3rd cubital	L	Axillary	34–35	2nd of anal		
12–7	1st transverse			34–30	Nervulus		
13–8	2nd cubital			36	Axillary		
15–18	Medial						
15–16	1st abscissa						
16–17	2nd of						
17–18	3rd medial						
16–10	Basal						
17–12	Recurrent						
17–12′	Recurrent						
17–12″	Recurrent						
18–19	Nervus parallelus						
20–22	Anal						
20–21	1st abscissa of anal						
20–21″	1st abscissa of anal						
21–22	2nd abscissa of anal						
21′–22	2nd abscissa of anal						
21″–22	2nd abscissa of anal						
21–16							
21′–16	Nervulus						
21″–16″							
23	Axillary						

NOTES ON A BRACONID PARASITE OF THE PINK BOLL-WORM (*PLATYEDRA GOSSYPIELLA*, SAUND.) IN KENYA COLONY.

By T. W. KIRKPATRICK, M.A., F.E.S.,
Assistant Entomologist, Department of Agriculture, Nairobi.

During November 1926, a few days were spent in making a rapid investigation of the insect pests of cotton occurring on the coast of Kenya Colony, between Mombasa and Mambrui, some eighty miles to the north.

The pink boll-worm, *Platyedra gossypiella*, Saund., was found to occur in every plot of cotton visited; it was also noticed that a certain proportion of the worms were parasitised by a species of Braconid, which has been described above by Mr. D. S. Wilkinson under the name of *Microbracon kirkpatricki*.

A second visit was paid to the coast during the beginning of February 1927, to ascertain to what extent, if any, the pink boll-worm was controlled by this parasite, and to report on the possibilities of its introduction to other countries.

Owing to the short time available for this work, these notes are naturally very incomplete; it is hoped however that they will be of some value should anyone be of the writer's opinion that it is well worth while attempting to introduce this parasite into other countries.

Cotton Cultivation and Climatic Conditions on the Coast of Kenya Colony.

Cotton is sown about the end of May or beginning of June, the first bolls ripen towards the end of October, and the picking season finishes in March. The Kenya Cotton Ordinance, 1923, lays down that all cotton plants must be uprooted and burnt by a certain date, usually on the coast about 21st March, though the actual date is fixed anew each year. There is thus, theoretically, a close season for cotton of about two months each year.

The climate of the coast is comparatively equable throughout the year, as may be seen from the following figures kindly supplied by the Statistical Officer of the Department of Agriculture:

Mombasa.—Average figures for the years 1916–1919 *inclusive.*

Month.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Average maximum shade temperature (°F.)	85·0	84·5	86·0	84·0	82·0	80·0	79·0	79·0	80·5	82·0	84·0	85·0
Average minimum shade temperature (°F.)	74·0	74·0	75·5	74·0	72·0	70·0	69·0	68·5	69·0	72·0	75·0	74·0
Average rainfall (inches)	0·65	0·56	3·28	9·41	6·25	4·06	4·21	3·01	2·36	2·33	1·75	1·57

Under such climatic conditions, the resting stage or "long cycle" larva of the pink boll-worm does not occur. During the close season, when (or if) there is no cotton available, it is presumed that the pink boll-worm breeds on one or more of the several wild Malvaceous plants common in the district, of which *Abutilon ? zanzibaricum* appears to be one of the most likely alternative host-plant. It is true that no trace could be found of the pink boll-worm in seed-capsules of *Abutilon* or of any other plant (though *Earias insulana* was found breeding on *Abutilon*), but it is probable that this is due to its preference for cotton when available.

Although both the pink boll-worm and its parasite were more numerous in the neighbourhoods of Malindi and Mambrui, where it was clear that the regulations for a close season had not been enforced, yet they were also both fairly common on the only plot of cotton on Mombasa Island, which is a Government demonstration plot, where the prescribed close season is naturally adhered to rigidly.

Notes on the Life-History of the Parasite.

Oviposition was only observed once—in captivity. The female thrust her ovipositor, which is about 1·7 mm. long, three-quarters of its length into a cotton seed in which a larva of *Platyedra* was feeding. So far as could be ascertained the ovipositor was inserted into the broken part of the seed, not through the testa.

The number of eggs laid by each female, or in each larva, is not known, but the most usual number of parasites to emerge from each larva appears to be two or three, four having been observed in one instance.

The individual duration of the egg, larval and pupal stages is not known ; the total life-cycle was however completed in certainly not more than 27 days, and possibly in as few as 19, in the Laboratory at Nairobi, where the temperature ranged approximately from 65° to 75°F. Presumably it would be considerably shorter in the warmer climate of the coast.

When the larvae of the parasite are full-bred, they leave the now almost completely shrivelled body of their host, and after a few hours (perhaps as much as a day) construct a tough white cocoon, usually either in the cotton lint, or in the seed that has been hollowed out by their host. No hyperparasite of this species has been observed.

Parasitisation of Platyedra Larvae in green and open Bolls.

Some 360 opened bolls were collected between the 12th and 15th February 1927, these being chosen as likely to contain pink boll-worm larvae, so far as could be judged from a superficial external inspection. From these emerged 35 *Platyedra* moths, and approximately 300 parasites. (The actual number of parasites is unfortunately not known, as there was considerable mortality among them due to the inadvertent introduction of some spiders with the bolls into the breeding cage ; 300 is probably if anything an under-estimate). Taking an average of 2·75 parasites to a parasitised larva (a figure based on admittedly insufficient evidence) these 360 bolls would have contained approximately 145 caterpillars, of which 110, or 76 per cent., were parasitised.

From 102 unsplit green bolls, collected at the same time in the same cotton fields, 12 pink boll-worm moths and 26 parasites emerged. Thus it is probable that about 44 per cent. of the caterpillars in these green bolls were parasitised.

Some of these green bolls had exit holes made by previous pink boll-worms, or the large hole made by the larvae of *Earias*. It is therefore not certain whether the parasite can oviposit through the carpel wall of the boll, or whether, when parasitised larvae are found in unsplit bolls, an entrance has been made by the female through a hole in the boll.

It is probable that the parasite usually oviposits into caterpillars that are nearly full-fed ; at any rate when this is done, the parasites are able to complete their development. No case has been observed of a parasitised larva pupating.

The Longevity of the Adult Parasite.

The following observations were made with a view to ascertaining the length of time the adults will remain alive, in case it should be thought worth while to attempt their introduction to other countries. It is not known how long they normally live under the climatic conditions prevalent at the coast.

At the Nairobi Laboratory, with the approximate temperatures of 73°-75°F. maximum and 64°–66°F. minimum, the following results were obtained,

(1). Twelve parasites emerged on 17.ii.1927 at Mombasa. These arrived at Nairobi on 18.ii.1927. On 26.ii.27 all were alive except one. By 3.iii.27 (*i.e.* after 14 days) six were dead. On 9.iii.27 (*i.e.* after 20 days) the last one died. No water or food was given except such as might have been found on the cotton bolls from which they were bred.

(2). The parasites emerging from the 360 bolls previously mentioned. A few had already emerged on arrival at Nairobi on 18.ii.27. Approximately 50 were still alive on 9.iii.27. There was then a considerable mortality, mainly due to spiders, and on 12.iii.27 only three remained alive. These three were dead by 18.iii.27.

Parasites kept in Cold Storage.

A batch of 18 parasites, 7 males and 11 females, which emerged on or before 21.ii.27, were kept in an ice-box from 22.ii.27 until 11.iii.27. Owing to an irregular supply of ice it was not possible to keep the temperature constant, and the figures were as follows :—

			FEBRUARY.					
Date	22	23	24	25	26	27	28	
Max. (°F.) ...	67	53	58	62	52	55	65	
Min. (°F.) ...	53	50	52	52	49	50	55	

				MARCH.							
Date	1	2	3	4	5	6	7	8	9	10	11
Max.	53	57	53	57	63	53	57	60	55	61	67
Min.	51	52	49	51	53	50	51	51	50	55	61

On 11.iii.27, the majority being still alive, they were removed from the ice-box and kept at the ordinary Laboratory temperature. By 18.iii.27, about half were dead, and on 21.iii.27 all were dead except four females and one male. These five however appeared quite vigorous. No water or food was given to them at any time, unless (*a*) any suitable food was contained in the dry cotton boll enclosed with them, or (*b*) there was any condensation of moisture inside the box when it was put into the ice-chest.

It therefore appears that this parasite can be easily kept alive for three to four weeks at moderate or low temperatures.

Experiment on the Possibilities of Breeding in Captivity.

On 19.ii.27, three last-instar pink boll-worm larvae were extracted from externally sound green boll and put in a box with 4 male and 5 female parasites. The boll-worms were given cotton seeds upon which to feed. Although frequent inspections were made, copulation was never noticed ; the act of oviposition was observed once only, on 27.ii.27. The last parent parasite died on 5.iii.27.

On 18.iii.27 four parasites emerged, and three more on 20.iii.27. All three boll-worms had been parasitised. All the seven parasites which emerged were males. It is therefore suggested that copulation did not take place, and that, as is the case with certain other Hymenopterous parasites, the offspring of unfertilised females are always males. If this is so, it should not be difficult to ascertain the conditions necessary for copulation ; possibly food of some sort is required.

It can be assumed practically with certainty that the three boll-worms were not already parasitised when they were removed from the bolls, as if that had been the case, the parasite would have emerged from them very much earlier. The date of the last emergence of any parasites from larvae in green bolls collected at the same time as those used in this experiment was 28.ii.27.

The Amount of Control effected by this Parasite.

No accurate estimation was made of the boll-worm population in November or again in February. The impression was however formed that it was scarcely if at all greater towards the end of the picking season, possibly even slightly less. Both in November and in February there were probably about 20–25 per cent. of the bolls attacked by pink boll-worm ; except for the parasite, it is more than likely that the percentage of attack would by February have reached 90–100 per cent. The percentage of parasitised caterpillars had undoubtedly increased enormously by February.

Conclusions.

It would appear that it would be by no means difficult to import this parasite into other countries where it might be of value. Whether it could ever adapt itself to live in a country where there is a definite winter, which is passed by the pink boll-worm as a resting larva, is a matter of conjecture ; it would however probably be quite easy to breed the parasites artificially during the winter on the resting larvae in " double " seeds.

ON SOME APHIDES INFESTING TULIPS.

By J. Davidson, D.Sc.,
Rothamsted Experimental Station, Harpenden.

(Plate III.)

During 1925–1926 a number of tulip bulbs and iris corms infested with Aphides were received from various sources, as well as Aphides from growing tulips. These species were reared and observations made on the progress of the infestation on tulips. It is evident that one species *Anuraphis tulipae* (B. de Fonsc.) is a serious pest of stored bulbs, especially tulips, and another species, *Rhopalosiphoninus tulipaella* (Theo.), may also be of importance in this respect. Since these two species are not well known, it may be desirable to give detailed drawings of the species together with some notes on the observations made. It is hoped that the complete life-cycles and alternative food-plants of these species may be traced later.

In addition to the two species mentioned above, *Macrosiphum gei* (Koch) and *Myzus persicae* (Sulz.) were also found infesting tulips.

Anuraphis tulipae (B. de Fonsc.).

1841. *Aphis tulipae*, B. de Fonsc., Ann. Soc. Ent. Fr., x, p. 167.
1908. *Aphis* sp. on Gladioli bulbs, Felt, Jl. Econ. Ent., i, p. 330.
1909. *Aphis gladioli*, Felt, New York State Mus. Bull. 134, 24th. Rept. (1908) State Entomologist, p. 19, figs. 6–9.
1923. *Anuraphis tulipae* (B. de Fonsc.) Theobald, Bull. 3, S. E. Agric. Coll., Wye (Advisory and Research Dept.) pp. 1–7.

Alate viviparous female (fig. 1).

Head and thorax brown to dark brown ; abdomen dirty yellowish to dirty white, often exhibiting a faint shade of pink, a dark irregularly shaped area extending over three or four segments ; the ventral surface of abdomen is a dirty yellowish-white.

Head. *Eyes* dark (dark red in earlier stages) ; two well defined pores situated between the eyes, near the median line ; (there are also two of these pores on prothorax and two or four near extremity of abdomen). *Antennae* fuscous, sometimes quite dark, about five-sevenths length of body, segt. i wider than ii, ii slightly longer than i, iii about five times length of ii, iv about half length of iii, v slightly shorter than iv, and vi about as long as ii + iii ; segt. iii is somewhat broad and bears about 45 sensoria distributed over its length ; segt. iv also bears 8–12 sensoria ; a few hairs on all segments. Thorax. *Wings* comparatively large, nervures and stigmatic areas greyish brown. *Legs* dirty yellowish-brown, distal ends of femora and tibiae darker, also tarsi. Abdomen. Usually 4 pairs of small, blunt tubercles can be seen on lateral margins ; two well-defined circular pores (and often two smaller ones) situated near median line, behind cauda. *Cauda* dark, short (about length of basal portion of antennal segt. vi), spinose, bearing two long, curved hairs on each side and one median sub-apical hair. *Anal plate* strongly rounded, spinose, bearing several long stout hairs ; *genital plate* round and furnished with stout, short bristles near distal border. *Cornicles* dark, imbricated, short (about as long as antennal segt. iv), nearly twice length of cauda, cylindrical, sometimes faintly expanded towards base, with a marked local constriction at base, particularly on inner face.

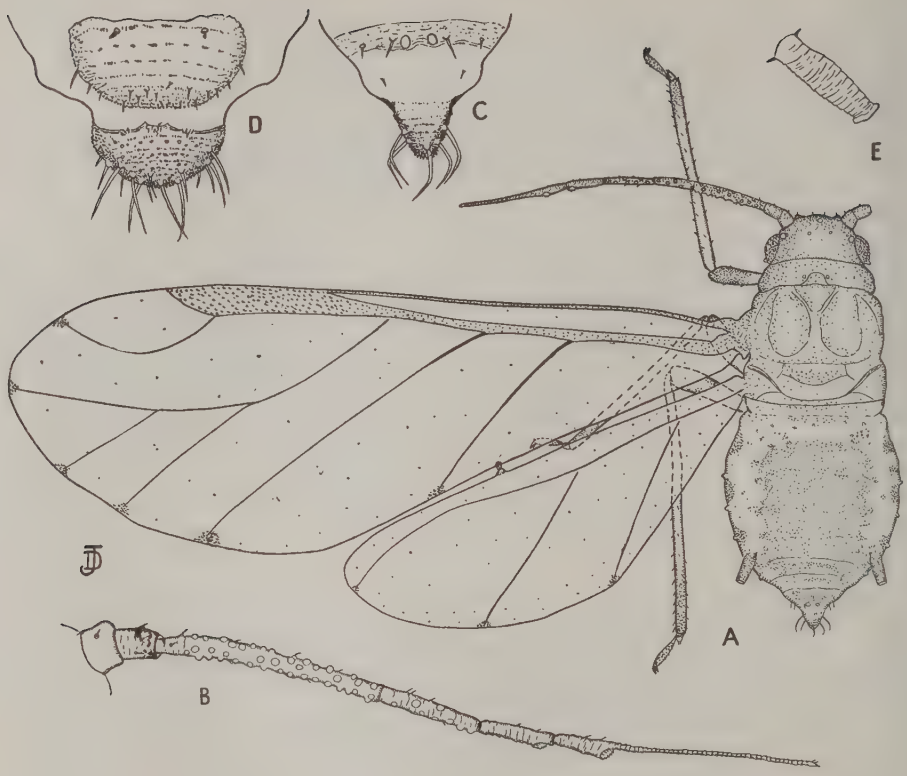

Fig. 1. *Anuraphis tulipae* (B. de Fonsc.) : A, winged v. ♀ ; B, antenna ; C, cauda (dorsal view) ; D, anal and genital plates (ventral view) ; E, cornicle.

Apterous viviparous female (fig. 2).

Dirty yellowish-white to greyish-white with darker head and thorax ; the younger stages are soft, velvety greyish-white, sometimes pale pink ; abdominal segments with darker transverse areas and a few small, dark spots in rows down the body ; the venter is a pale, dirty yellowish-white, somewhat velvety.

Head. Two circular pores in line with the eyes, near median line ; *Eyes* black. *Antennae* slightly less than half length of body ; greyish brown to fuscous ; distal end of segts. iii–v darker and also segt. vi ; segt. i much stouter than ii, but ii a little longer, iii about four times length of ii, iv nearly three times length of ii, v longer than iv but not as long as iii, vi about as long as iv+v ; a few hairs on all segts. Thorax. *Legs* dirty greyish-white, tarsi dark as also coxae and distal end of tibiae. Abdomen. A few short hairs on all segts ; facets of wax-glands faintly showing in two irregular longitudinal rows ; four small, blunt, lateral tubercles on posterior half. *Cauda* fuscous to dark, small (about length of antennal segt. i), and scarcely projecting beyond abdomen, spinose, with two curved hairs on each side and one median subapical one ; two prominent pores near median line with two adjacent smaller ones situated on abdominal segt. behind cauda and two other smaller ones on the adjoining segt. *Anal plate* dark, rounded, spinose, bearing several long hairs ; *genital plate* round and furnished with many short bristles near distal border. *Cornicles* dark,

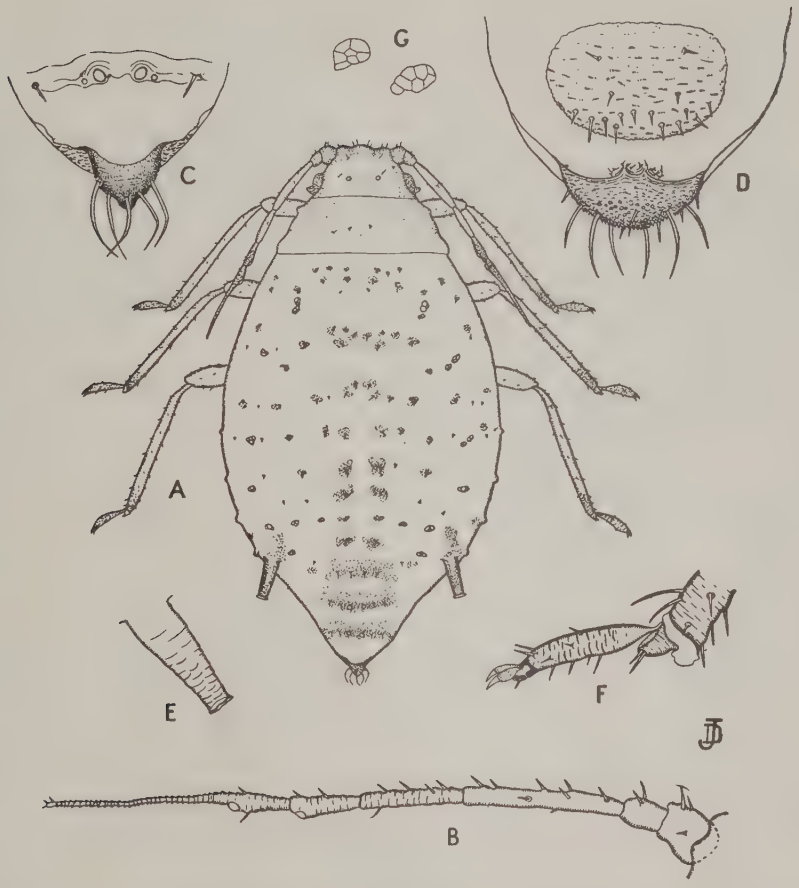

Fig. 2. *Anuraphis tulipae* (B. de Fonsc.) ; A, apterous v. ♀ ; B, antenna ; C, cauda (dorsal view) ; D, anal and genital plates (ventral view) ; E, cornicle ; F, tarsus of 3rd leg; G, facets of wax glands.

cylindrical, short (about 3 times length of cauda, and width at base about one-third of length), sometimes faintly expanding towards the base, but slightly constricted at the apex.

Male.

I did not find any sexual forms in my material, so reproduce here the description given by Theobald (1923).

" Alate. Head and thorax brown. Abdomen fawn colour, with dark dorsal area and dark lateral spots. Antennae dark brown, much longer than body ; first segment larger than second ; third the longest, with 54 to 60 pale sensoria ; 4th long, a little longer and thicker than fifth, with 42 to 48 sensoria ; fifth with 12 to 16 sensoria ; basal area of sixth nearly quarter the fifth ; flagellum moderately long. Cornicles cylindrical, rather thin, nearly as long as fifth antennal segment ; rather more than

three times as long as hind tarsi. Cauda small, scarcely projecting, with two hairs each side. Penis blunt, yellow; claspers black. Wings large. Proboscis not reaching the second coxae.

Length 1·5 mm."

Sexual female. Unknown.

This species, first recorded in 1841 by Boyer de Fonscolombe, has received little attention in the literature, except by Felt in 1908 and 1909 and Theobald in 1923. The food-plants and localities from which it has been collected are given by the latter author. The writer received a number of tulip bulbs from a London store house (7th November 1925) and again in 1926 and also some iris corms (21st November 1925), which were infested with this species. There were a few Aphids on most of the bulbs, and they rapidly increased in numbers when the latter were planted in sand in the glasshouse. The insects were found beneath the dried outside sheath covering

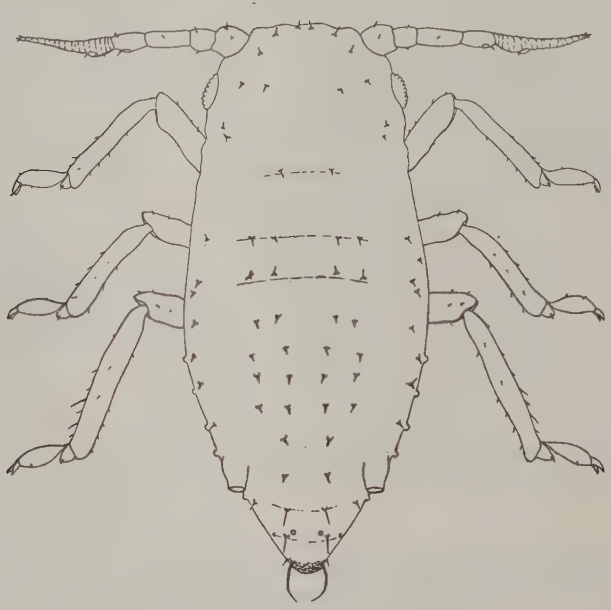

Fig. 3. *Anuraphis tulipae* (B. de Fonsc.), first stage larva born from apterous v. ♀, dorsal view.

the bulb and the apterous forms cluster in the dark depressions and crevices of the bulb, shunning the light. This aphis was reared in large numbers on tulip and iris bulbs in the greenhouse during the winter 1925–6. Many winged forms were produced, some of which reproduced on the bulbs, but large numbers of them were strongly attracted to the light, and when infested bulbs were placed in a glass chamber in the laboratory, the winged forms invariably collected at the top of the glass vessel on the side facing the window. Some tulip bulbs slightly infested with apterous v. females were planted in sand on 8.xi.1925. The Aphids reproduced strongly and as the bulbs began to throw up the green leaf-spathes, some of the Aphids clustered over them. By 14th December some winged v. females developed, and by 4th January there were large numbers of winged forms, and the young green spathes of the developing tulips were smothered with Aphids. The check to the growth was very

severe, and by 13th January, in some cases, the green shoot became brown and died, and in others only a badly distorted shoot developed. This is well shown in the photograph (Plate iii). Many of the winged forms reproduced on the tulip bulbs and produced apterous v. females. The insects prefer the bulb portion of the plants and do not infest the leaves of growing tulips, and the colonies died out as spring advanced. Infested iris corms were also grown, and the Aphids reproduced in large numbers on them, masses of winged v. females being produced.

Many hundreds of alate forms were examined from the material, but no males were found. Alate v. females were isolated and their progeny observed, but in all cases they produced apterous v. females, and no sexual females were recorded, the alate forms consisting only of virginoparae.

Boyer found this aphis on tulip bulbs lifted for storing in November, and Theobald (*l.c*) recorded males being produced at end of November.

The evidence available strongly indicates that this species is a migrating form of the usual APHIDINI type, tulip bulbs being one of its intermediate food-plants. The alienicolae have semi-subterranean habits and are able to carry on parthenogenetic reproduction freely throughout winter, under favourable conditions. Such conditions are fulfilled in the case of tulip and other bulbs stored in warehouses.

Since males have been recorded in the colonies on bulbs at the normal period when males and alate sexuparae return to the primary host, one might reasonably expect that some of the alate v. females produced at the same time would be sexuparae and would produce sexual females. These have not been recorded however, and it may be that the sexual females are not produced or fail to develop on this (intermediate) food-plant.

It would appear that normally the bulbs are infested in the field before they are lifted for storing, and the primary host of this aphis remains as yet unknown. It is possible that, as a result of the insects being transported on infested bulbs from one country to another, in some countries the association with the primary host may have been lost owing to the absence of the latter.

It is clear that this species is an important consideration for bulb-growers and importers of bulbs. It is often difficult to say whether a particular bulb is infested or not, owing to the habit of the Aphids in getting into the dark crevices of the bulb, and one or two individuals, if present, will soon produce a large colony under suitable temperature conditions. Treatment of infested bulbs and isolation from clean ones is desirable where possible.

Rhopalosiphoninus tulipaella (Theo.).

1916. *Rhopalosiphum tulipaella*, Theo., The Entomologist, xlix, pp. 146–9.
1926. *Rhopalosiphoninus tulipaella*, Theo., British Aphides, i, pp. 220–3.

Alate viviparous female (fig. 4)

Head and thorax black, shiny, with a pale yellowish-green, transverse band anterior and posterior of pronotum ; abdomen with black transverse patches, the intervening areas being a pale, dirty yellowish-green ; these dark areas fuse more or less irregularly in the posterior region, which thus appears brownish-black and shiny; small dark patches along lateral margins of abdomen ; on the ventral side meso-and meta-thorax black and shiny, remainder of body dusky yellowish-green, sometimes with small transverse darker areas extending from margins of abdomen.

HEAD. Frontal lobes well developed, surface somewhat roughened with small chitinous papillae ; head with several finely capitate hairs ; rostrum extending to coxae ii. *Antennae* dark to black, basal segments paler, slightly longer than the body ; segt. i broader and slightly longer than ii, iii about five times length of i, iv slightly

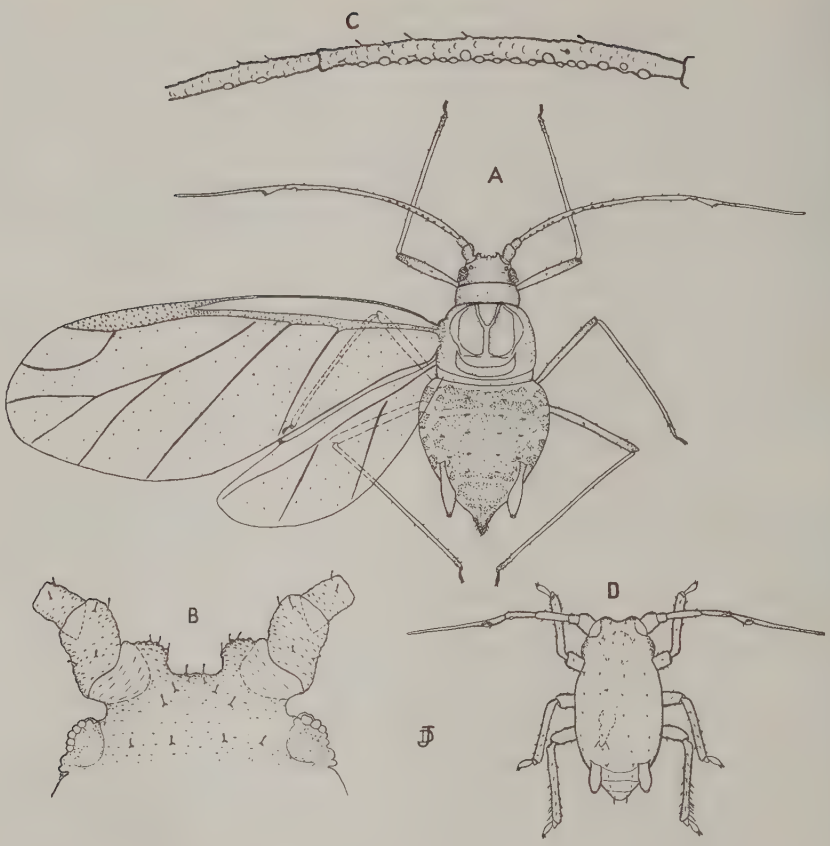

Fig. 4. *Rhopalosiphoninus tulipaella* (Theo.) : A, winged v. ♀ ; B, head (dorsal view) ; C, segments 3 and 4 of antenna ; D, first stage larva born from apterous v. ♀, dorsal view.

shorter than iii and slightly longer than v, v about five times length of ii, vi about as long as i +ii+iii ; a few short, faintly capitate hairs on all segments ; a varying number of about 12–18 sensoria along inner margin of segt. iii and about 2–5 on basal portion of segt. iv. THORAX. *Wings.* Veins dark, well defined, bordered on each side with a faint narrow, dusky area ; stigma dark. *Legs* with coxae dark, distal half of femora dark, tarsi and tibae dark, basal portion of femora and tibiae paler. ABDOMEN dark, 4 longitudinal rows of small, facetted areas (wax glands). *Cauda* dusky brown, conical, finely spinose, about as long as basal part of antennal segt. vi ; two pairs of lateral hairs and one median sub-apical hair. *Anal plate* rounded, bearing a few hairs ; *genital plate* normal. *Cornicles* dark with irregular lighter patches, about length of antennal segt. iv or v, prominently vasiform, being swollen about one-third length from distal end, usually particularly on the internal face, basal portion narrow, cylindrical, a few well marked reticulations at the apex.

Apterous viviparous female (fig. 5).

Yellowish-greenish-brown, shiny ; head dirty yellowish-green ; thorax with a dark transverse band on each segt ; abdominal segts. with irregular darker transverse

bands, more or less segmentally arranged and running together in the region of the cornicles ; a row of small dark patches along lateral margins of the body ; sometimes the insect looks quite dark owing to the dark areas on the abdomen ; venter paler, dirty yellowish green, shiny.

Head. Frontal lobes well developed ; head with several small, finely capitate hairs ; *eyes* dark. *Antennae* slightly longer than the body, pale ochreous to dirty yellowish-green, apices of segts. darker, as also proximal portion of segt. vi ; segt. i wider and slightly longer than ii, iii about eight times length of ii, iv about four times length of i, v slightly shorter than iv, vi about as long as iv+v ; segt. iii with 2–3

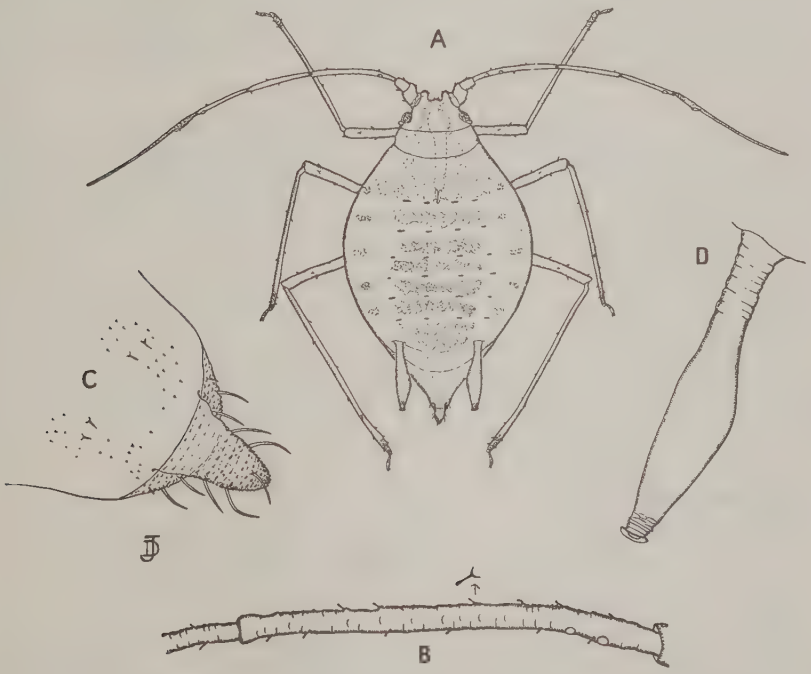

Fig. 5. *Rhopalosiphoninus tulipaella* (Theo.) : A, apterous v. ♀ ; B, segment 3 of antenna ; C, cauda and anal plate (dorsal view) ; D, cornicle.

sensoria near its base ; a few faintly capitate hairs on all segments. Thorax. *Legs* pale to dirty yellowish-green, tarsi darker, as also distal end of femora and tibiae. Abdomen. Four longitudinal rows of small facetted areas (wax glands) faintly developed. *Cauda* pale yellowish-green to brownish-green, conical, finely spinose, about one-fifth length of cornicles and about length of antennal segt. i, with two strong hairs on each side, and one median subapical hair. *Anal* plate rounded, with a few hairs ; *genital* plate normal. *Cornicles* dark at base and apex, paler about the middle, as long as or slightly longer than antennal segt. iii, prominently vasiform, usually slightly more swollen on internal face, narrow and cylindrical towards proximal end, with a few reticulations at the apex.

Male. Unknown.

Sexual Female. Unknown.

This species was first described by Theobald in 1916 (*l.c.*) from tulips and violets. Tulip bulbs received by the writer from Wisbeach on 7.xii.1925 were slightly infested with a few immature forms. The bulbs were planted in sand in a glasshouse, and by the 18th December several adults were present and small colonies going well. By 13th January 1926 the leaves of the bulbs were well forward and the Aphids developed readily on the young leaves, the plants being heavily infested, as is shown in the photograph (Plate iii). In many cases the leaves were distorted as they unfolded, owing to the effects produced by the Aphids, and were brown and shrivelled at the tips. By the 27th January most of the plants were heavily infested with winged and apterous forms and were severely damaged by them; in some cases the leaves of the tulips failed to open and became discoloured, eventually dying. At the end of October 1925, some tulip bulbs were received from Llandudno; it was stated that the bulbs had been in a sack for about three weeks; they were slightly infested with *R. tulipaella*. Tulip bulbs slightly infested with this species were also received from Merton in December 1925.

In the case of this species, only a few isolated Aphids were found on the bulbs, which contrasts with the case of infestation with *Anuraphis tulipae*. The fact that colonies of *R. tulipaella* progressed so readily on the leaves indicates that this is the more normal habit (which contrasts with the habits of *A. tulipae*), although they can live on the dormant bulbs and by this means are readily distributed. Theobald records that this species also lives in the tulip blossoms.

The alate v. females produced apterous v. females and, as Theobald has pointed out, the offspring of the former are yellowish white in colour, while those of the apterous v. females are darker.

Although large numbers of the insects were reared, no sexual forms were obtained, and it is evident that the species is able to reproduce parthenogenetically throughout the winter. Like *A. tulipae*, it is able to live on the stored bulbs during winter and start the infestation of the developing leaves in the spring.

Macrosiphum gei (Koch).

1855. *Siphonophora gei*, Koch, Die Pflanzenläuse Aphiden, p. 171.
1926. *Macrosiphum gei* (Koch), Theobald, British Aphides, i, p. 108.

Winged viviparous female (fig. 6.).

Body light to dark green, head somewhat darker with a narrow dark border along posterior margin, thorax dark green to brownish, abdomen yellowish green; the ventral surface light green with thorax darker green.

Head. Somewhat narrow, with many finely capitate hairs; *eyes* black; *ocelli* well developed. *Antennae* with the two basal segments pale green, remainder dark or fuscous; as long as or longer than the body; segt. i wider and a little longer than ii, iii about ten times length of ii, iv about eight times length of ii, v slightly shorter than iv, vi nearly as long as iv+v; iii with about 14 sensoria in a row along its internal face, extending about three-fourths of length of segt.; several small, faintly capitate hairs on all segments. Thorax. *Wings* with well-defined dark veins and greenish-brown stigma. *Legs*, coxae and trochanters green, femora and tibiae somewhat darker green and darker at distal ends, tarsi dark. Abdomen. Elongate, with rows of short hairs on all segments. *Cauda* not quite half length of cornicles, pale green, ensiform, finely spinose and bearing several lateral hairs and one or two subapical, median hairs. *Anal plate* rounded, spinose and bearing a few long hairs; *genital* plate normal. *Cornicles* yellowish green basally, darker on distal portion, about as long as antennal segt. iii, slender, tapering distally, reticulate at distal end for about one-fifth of its length and the surface sculptured over remaining portion.

Apterous viviparous female.

Body green to yellowish green, more or less uniformly yellowish green on the venter.

HEAD green, bearing a few short hairs; *eyes* black; *rostrum* yellowish green, darker at distal end, reaching to coxae ii. *Antennae* as long as or longer than the

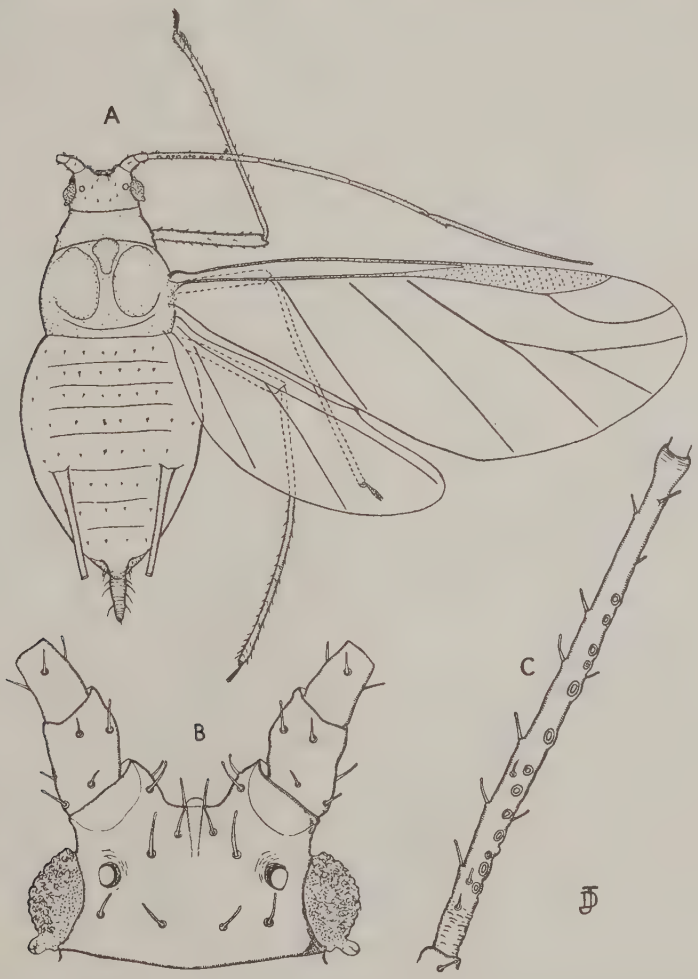

Fig. 6. *Macrosiphum gei* (Koch), from tulips: A, winged v. ♀; B, head (dorsal view); C, segment 3 of antenna.

body, fuscous, apex of segments darker and also the whole of segt. vi; segt. i wider and slightly longer than ii, iii about nine times length of ii, iv about eight times length of ii, v about seven times length of ii, vi about as long as iv+v; iii with a few (about 3) round sensoria on inner face, near its base; all segts. with a few faintly capitate hairs. THORAX. *Legs* yellowish green with dark tarsi and distal end of tibiae and femora dark. ABDOMEN elongate, with rows of short hairs on all segments. *Cauda*

slightly less than half length of cornicles, pale green, ensiform, finely spinose, bearing several lateral hairs and one or two sub-apical, median hairs. *Anal plate* and *genital plate* as in w.v. female. *Cornicles* pale green basally, darker on distal portion, about as long as antennal segt. iii, reticulate at distal end for about one-fifth of the length.

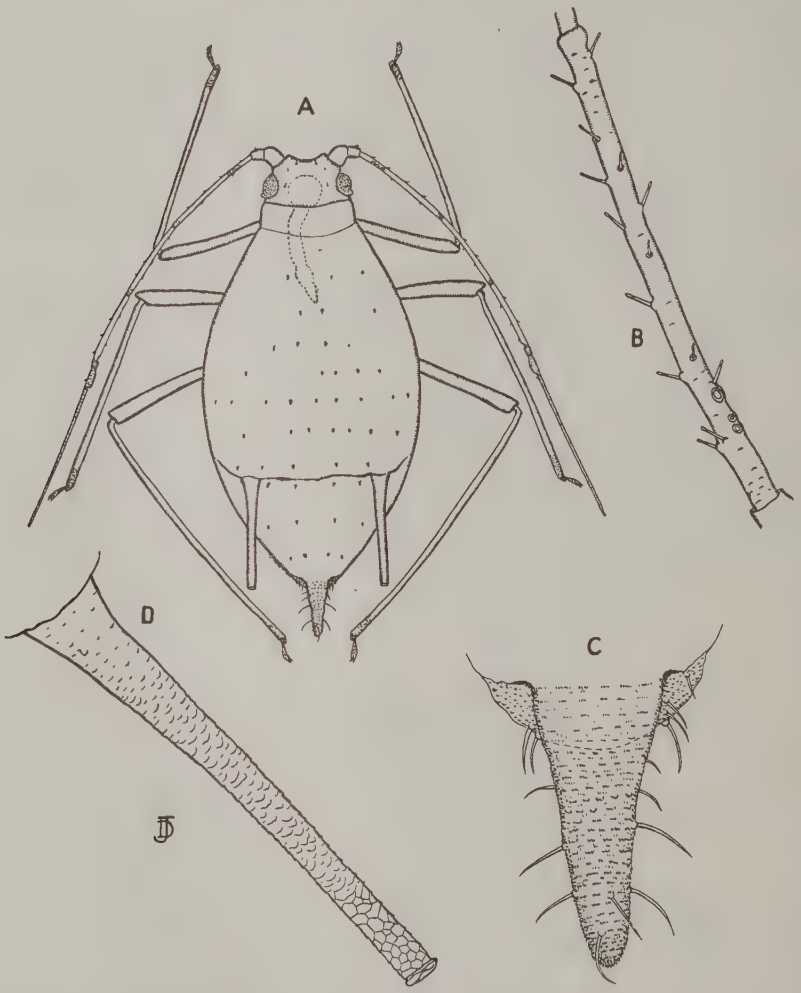

Fig. 7. *Macrosiphum gei* (Koch), from tulips: A, apterous v. ♀; B, segment 3 of antenna; C, cauda and anal plate (dorsal view); D, cornicle.

Male. See Theobald (*l.c.*, p. 110).

Oviparous female. See Theobald (*l.c.*, p. 111).

Material from which these descriptions and drawings were made were received from Mr. Miles from Gloucester, 9.iii.1926, having been collected on tulips which were just appearing above ground. They were reared on tulips in the Rothamsted insectary glasshouse, on which they produced large colonies, the plants being heavily

infested by the end of April. This Aphid was also collected by myself on tulips at Harpenden, 9.vi.1926, and the same species was received through Mr. Stenton from tulips at Spalding, Lincs., 15.iii.1926.

The insect fits Koch's description of *gei*, which Theobald (*l. c.*) has shown to be the same species as *Macrosiphum solanifolii* (Ashmead). This widely polyphagous species has many varied food-plants and can reproduce parthenogenetically throughout winter under favourable conditions. Miss Patch (Maine Agric. Expt. Sta. Bull., no. 242, 1915, pp. 205–223) shows that in America, rose trees are the normal winter host for the overwintering eggs of *solanifolii*. Theobald (Jl. Roy. Hort. Soc., 1925, i, p. 33) records *solanifolii* as common on tulips. I have not found this insect on dormant bulbs, the species having been collected only from the aerial portions of the plant.

Myzus persicae (Sulz.).

1776. *Aphis persicae*, Sulzer, Abgek. Gesch. Ins. p. 105, pl. xii.

This widely polyphagous species frequently occurs on tulips, and its presence on many glasshouse plants and the fact that it readily reproduces parthenogenetically throughout the winter under favourable conditions, account for its presence on tulips in early spring. The writer has received specimens taken from tulips in March. This species has received considerable attention in the literature, and a good account is given by Theobald (British Aphides, 1926, i, p. 318).

Control Measures.

Anuraphis tulipae and *Rhopalosiphoninus tulipaella* are the two most important species associated with stored bulbs, and owing to the numbers of alate virginoparae which develop, it is evident that infested bulbs should be isolated and subjected to treatment in order to prevent widespread infestation of other bulbs in the warehouse. Theobald (1923, Bull. 3, p. 7) recommends half an hour's fumigation with tobacco shreds. Two minutes' immersion of infested bulbs in a bath of nicotine and soft soap ($\frac{1}{2}$ oz. nicotine, 95–90 p. c. and 2 oz. soft soap to 10 gals. of water) and afterwards allowing them to dry gradually was also found effective.

Recently Stenton (Jl. Min. Agric. 1926, xxxii, pp. 1037–1401) obtained good results by fumigating infested bulbs with dry crystals of paradichlorbenzene. The bulbs are placed in a fumigating box or chamber and exposed to the vapours of the paradichlorbenzene for not less than 48 hours; the quantity of crystals found to be effective was 4 oz. to a square foot for a single layer of bulbs. The fumigation was found to be more efficient when a cloth or blanket was dipped into a solution of paradichlorbenzene in carbon tetrachloride and, after being dried for a few minutes, placed between layers of bulbs in the fumigation box, instead of the loose crystals between sacking as in the former method.

Essig (Insects of Western North America, 1926, p. 236) states that infested bulbs should be soaked for several hours in 1 part of 40 p.c. nicotine sulphate solution to 1,000 parts of water, or thoroughly covered for a like period in 2 p.c. pure nicodust.

In any case a close inspection of bulbs when received for storage in the warehouse is desirable, so that infested bulbs may be isolated for appropriate treatment.

Clean bulbs may become infested not only by the alate forms, but also by the apterous forms crawling from one bulb to another.

Tulips which are grown early in the season in glasshouses should be carefully watched for colonies of Aphids forming on the green leaf-spathes, which, where necessary, should be sprayed with a dilute soap-nicotine emulsion; it is more difficult to destroy the Aphids after the leaves open, owing to the fact that they get inside the folds of the young leaves. Moreover it is in the early stage of the young developing leaves that the damage occurs which leads to distortion of the plants.

SUPPLEMENTARY NOTE :—Essig (Insects of Western North America, 1926, p. 236) states that *Anuraphis tulipae* is common throughout California, being a European species which has been carried over the country on tulips, iris plants and bulbs. *Aphis viridis*, Del Guercio, is given as a synonym; presumably the latter species is the one noted by Del Guercio in 1900 (Nuov. Relaz. Staz. Agraria Firenze, ii, p 129).

Aphids infesting tulips; the two plants on the left are infested with *Anuraphis tulipæ* and the one on the right by *Rhopalosiphoninus tulipaella;* on the latter plant a small white colony of *A. tulipæ* is seen on the small leaf. Photograph taken on 13th January, 1926.

A CHART-RECORDING WEIGHING MACHINE FOR BEEKEEPING OR OTHER RESEARCH.

By C. B. Williams, U'
Director of the Plant Protection Service, Ministry of Agriculture, Egypt.

(Plate IV.)

In the course of the beekeeping work of this Department we have had a number of hives weighed at regular intervals of about a week by means of a steelyard and tripod, and two permanently standing on platform weighing machine and weighed every day. The information obtained from these has been of great value in showing the seasonal variation in activity, the periods of honey flow, and the effect on the hives of the presence of enormous numbers of hornets in the late summer.

There were, however, many problems, such as the daily periods of activity and honey-collecting, the effect of high midday temperature, etc., that could only be dealt with by more frequent weighings, and it was felt that a machine to record continuously the weight of the hive by means of a rotating clock drum and pen would be a most valuable instrument of research.

Enquiries in different directions failed to discover any such instrument on the market, except the extremely delicate electrical recording weighing machine in use at Rothamsted for recording minute changes in weight.

In the case of the work with the hives it was necessary to deal with total weights up to about 100 kilos, and daily changes up to at least two kilos (which was the maximum net gain in weight of our weighed hives on any one day in 1926). The sensitivity should be as great as possible, but as a single bee weighs only on an average about 0·2 grain, it was not expected to be able to record changes other than those due to a general activity affecting a hundred or more bees.

Enquiries were then made from a large manufacturer of weighing machines, who took considerable trouble in designing an apparatus for the purpose. Unfortunately, however, the estimated price (over £150) proved to be too high, and it was necessary for the moment to obtain something simpler and less expensive, although the greater delicacy of the designed machine was recognised.

After some experiment the machine described and figured below (Plate iv) was planned and built by adaptation from a personal weighing machine which was graduated to read to 50 grams up to a maximum weight of two hundred kilograms.

The machine in question had two sliding weights, one adjusting to every 10 kilos (Plate iv, fig. 1, E) and the other smaller one measuring the intermediate differences (F). Needless to say, however, the main principle of the machine could be adapted to almost any lever-weighing machine of this type.

In the first place the stop, which limited the up and down movement of the lever to a very close range, was removed, and the pen (C) from a recording thermometer was fastened to the end of the lever.

The most important point to arrange now was that an equal increase of weight should bring about an equal displacement of the bar and hence of the pen. This was done by fastening to the end of the lever bar a vertical glass rod (A), which descends into a trough of mercury (B) (or other liquid, see below). If an increase of weight occurs on the platform the lever tends to rise ; when this happens the glass rod rises in the mercury and the up-thrust on the rod is reduced, producing a new position of stability. Since the rod is of uniform diameter, an equal movement produces an equal displacement of mercury. Hence the scale, within small angular changes, is approximately linear.

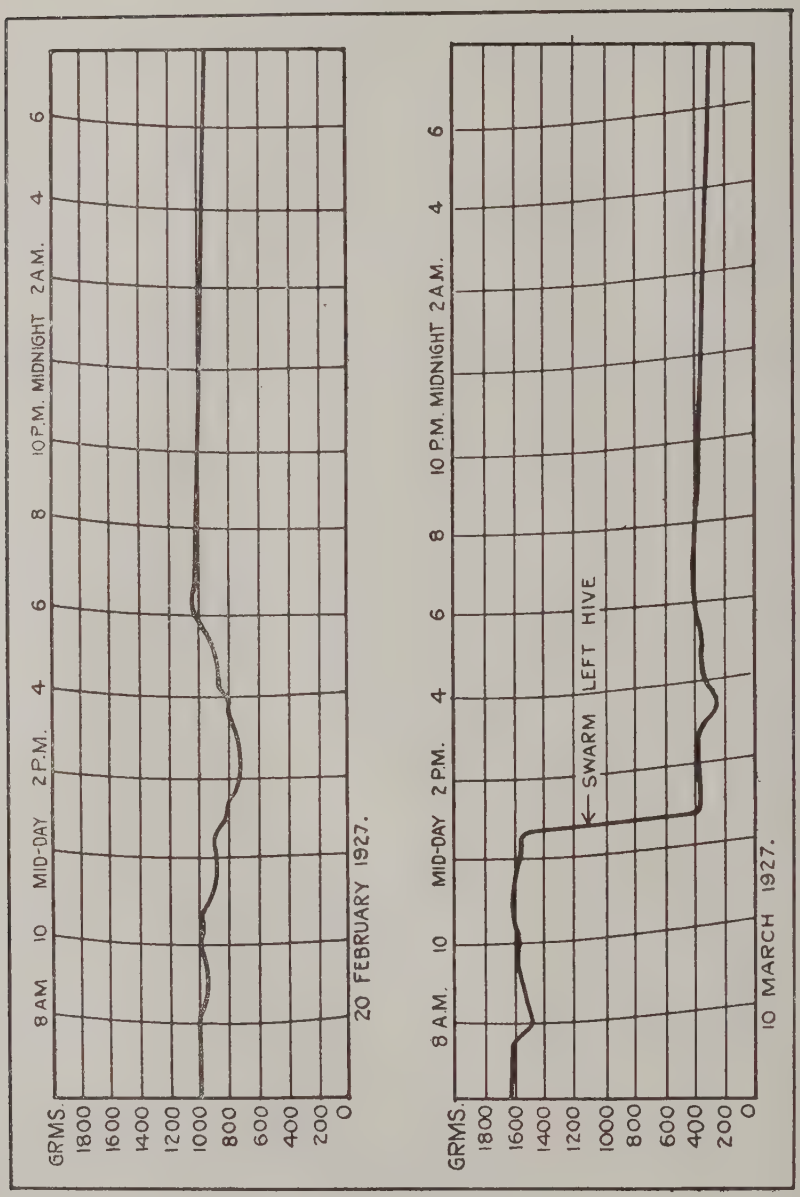

FIG. 1. Examples of records made by the weighing machine,

Further, if the rod is large in diameter, a small rise will produce a large difference in up-thrust; if the rod is narrow, a large movement is required and hence greater sensitivity can be obtained. The machine can thus be fitted with rods of various diameters each giving a separate scale, and the change from one to the other can be made in a few minutes to suit the purpose of the experiment.

Even greater alterations in sensitiveness can be obtained by using liquids other than mercury, but for work over long periods mercury would appear to be the most satisfactory, as water evaporates and oils tend to creep, both of which processes will result in a lowering of the liquid, and hence of the pen and the zero point of the scale.

To prepare for use, a known weight is placed on the platform. The large and small sliding weights are adjusted to indicate this weight, and the adjustable correction weights (G), at the other end of the lever arm, are adjusted till the pen is in the centre of the drum, which should be arranged so that this gives a horizontal position for the pen arm. The scale of movement, for the given vertical glass rod, can then be marked off experimentally either by adding or subtracting small weights to the platform, or by sliding the small adjusting weight to different positions. In the machine at present in use a change of weight of one kilogram produces a movement of the pen of about 21 mm. (see specimen in text—fig. 1).

The drum at present in use (supplied by Messrs. Baird & Tatlock) is six inches in diameter and rotates (according to adjustment) in either $3\frac{1}{2}$ or 7 days, but other drums are available for 12 and 24 hours or 15 and 30 minutes according to the class of work desired.

In order to get the best result the pen must press on the paper as lightly as possible, provided only that a mark is left. The "gate" principle embodied in the pens of Negretti & Zambra is very good from this point of view. To test the friction from this source the platform should be lightly pressed so as to give the pen an up and down swing. It should then return to a position very close indeed to its original position. If not, the pen must be cleaned, new ink added, and the pressure readjusted.

For use, the machine must be protected from wind, rain and dew, as all these affect the movement of the pen. After fixing the zero point and checking the scale as above, the hive is placed on the platform and the sliding weights adjusted till the pen is in the centre of the scale. This gives the actual weight of the hive. For convenience, however, it is frequently better to start the chart with the pen lower down on the scale, if increases of weight are expected during the period. At noted times each day the hive should be lightly touched to swing the pen, both to check the time scale and also to see that the pen is moving freely.

The illustrations show the complete instrument with a hive on the platform and a closer view of the recording mechanism (Plate IV). Although it is not intended to discuss here the results, it will be interesting to note how on 20th February the bees began to be active shortly after 8 a.m., there was a renewal of activity about 10.30 a.m., and still further activity about 12.30–2 p.m. From this time the bees returning with honey brought the weight steadily up till shortly before 6 p.m., when activity ceased with the weight of the hive slightly above what it had been at the beginning of the day. Then followed the usual steady, slow loss by evaporation during the night. The second diagram (10th March) shows outside activity of the bees shortly after 7.30 a.m., ceasing, however, between 10 and 12, and at about 12.40 a swarm weighing about 1,200 grams left the hive. There was renewed outside activity of the remaining bees between 3 and 4 p.m., but all ceased shortly after 6 p.m. When charts of this type can be checked against temperature, rain, wind, humidity and sunshine records, interesting information is bound to result.

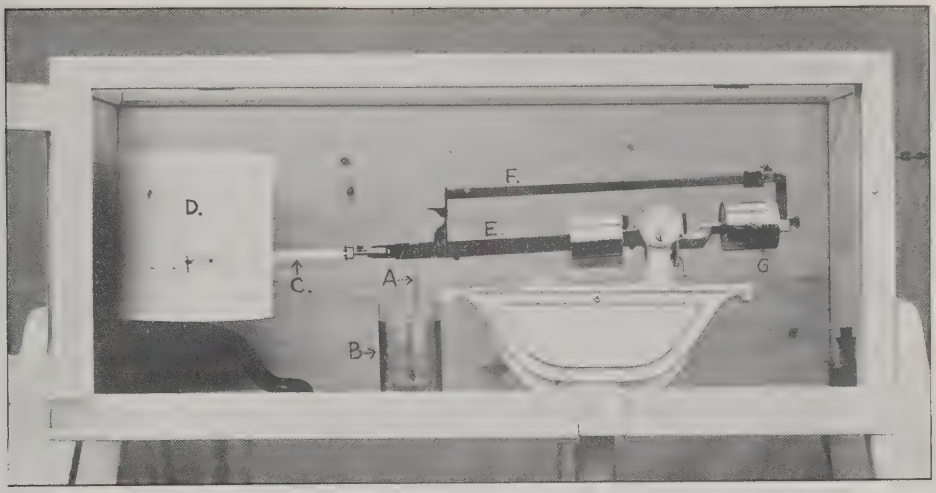

Fig. 1.

Fig. 2.

A chart-recording machine for weighing beehives.
(For explanation see text.)

TWO NEW SPECIES OF AUSTRALIAN CULICIDAE (DIPTERA).

By Frank H. Taylor,
The Australian Institute of Tropical Medicine.

The present paper contains the descriptions of two new species of mosquitos from North Queensland, *Mucidus chrysogaster* and *Aëdes* (*Finlaya*) *mackerrasi*. The former, the second Australian species of the genus, is a very interesting and most beautiful insect, of which only the female is so far known ; the latter is also of interest in that it adds yet another species to the closely interwoven group of Australian *Finlaya*.

My thanks are specially due to Dr. I. M. Mackerras, B.Sc., for his kind assistance in the determination of the latter species, since I was unable to do so myself, as the Institute does not possess a male specimen of *Aëdes* (*Finlaya*) *occidentalis* (Skuse). The comparative notes on the genitalia are from his pen.

No figures are published with this paper. They will be given in a subsequent publication.

Culex (*Culiciomyia*) *pullus* (Theo.) is here recorded for the first time from the mainland of Australia, having been taken in some numbers in the Innisfail district, North Queensland. Its larva and pupa will be described in a subsequent paper.

Mucidus chrysogaster, sp. n.

♀. *Head* densely covered with golden narrow-curved and dark upright forked scales, the latter very numerous ; a dense median row of sickle-shaped golden ones in the middle ; the narrow-curved golden scales round the eyes are very prominent, widening out laterally ; beneath is a small patch of black flat scales ; remaining flat scales golden. Clypeus large, prominent, testaceous ; palpi about one-quarter the length of the proboscis, densely covered with golden scales, except about the apical quarter, which is clothed with black scales and numerous black hairs, elsewhere these hairs being almost pale golden-brown, beneath the golden scales reaching almost to the apex ; there are also a few outstanding black scales above and beneath on the apex of the second joint, giving the palps a shaggy appearance ; proboscis covered with golden scales with irregular patches of black ones, labella large, reddish-brown, with dense, short, pale hairs. Eyes blue-black ; there are a few pale golden hairs overhanging the eyes in the middle. Antennae with basal lobes pale testaceous, with a few small flat golden scales on their inner surface ; second joint pale, considerably longer than the third ; the latter to the apex brownish ; pubescence pale, hairs of whorls brown. *Thorax* : scutum chocolate-coloured, covered with mixed golden and chocolate-brown, narrow-curved scales ; there is a moderately broad median transverse band of golden scales reaching right across the scutum, reaching this but not passing it is a broad (about a quarter the width of the scutum) stripe of golden scales ; the golden scales are very pronounced on the anterior margin of the scutum ; the lateral hairs are very dense above and in front of the wing-roots, reaching about two-thirds the distance to the prothoracic lobes, brownish-black above the wing roots, black elsewhere ; scutellum chocolate-brown, densely covered with pale golden sickle-shaped scales, posterior border bristles long, pale golden ; prothoracic lobes prominent, black, clothed with golden narrow-curved scales and numerous long black hairs ; metanotum chocolate-brown ; pleurae blackish brown, with pale golden flat scales in the middle ; halteres pale with dark knobs. *Abdomen* : first segment dark chocolate-brown covered with black flat scales, very hairy, the hairs blackish except on the apical margin, where they are pale golden, also a narrow, median, basal

patch of pale golden, loosely applied, flat scales ; segments 2 to 4, inclusive, black-scaled with pale lemon-coloured basal banding, broadest on the second and diminishing in width to the fourth, where it is very narrow, each with two small, submedian, basal, golden spots and golden, median, lateral patches, largest on the fourth ; third segment with a small subapical, golden spot toward the edge on either side ; fourth flecked with scattered golden scales ; segments 5 to the apex black-scaled, profusely mottled with golden scales ; all segments with golden hairs on the apical margin ; moderately numerous, pale golden hairs are to be seen on segments 5 to 7 inclusive ; cerci reddish brown, large, clothed with numerous pale hairs ; venter clothed with golden scales except the apex, which is dark-scaled. *Legs* : femora of fore legs black-scaled, heavily spotted with golden scales, with a basal golden band, knees golden ; tibiae black-scaled, profusely spotted with golden scales, apex golden ; first tarsal joint with basal golden banding, apex narrowly golden, remainder mottled black and golden ; second to fourth joints black-scaled with moderately broad basal banding, fifth golden with a few scattered dark scales ; femora, tibiae and tarsi of mid legs similar to those of the fore legs, except that the mottling is not so pronounced on the first tarsal joint and the fifth tarsals are entirely golden ; femora and tibiae of hind legs similar to those of the fore and mid legs ; first tarsals black-scaled, not mottled, with a basal golden band, second tarsal black with basal golden banding, third and fourth tarsals black with creamy-white basal banding, fifth tarsal creamy-white ; ungues of all legs only slightly curved, equal, each with a small tooth. *Wings* with the base of the veins clothed with dense, black scales ; all the cross-veins and the bases of the second and fifth longitudinal veins with dusky clouding, which extends into the cell for some distance immediately above the base of the third long vein(R_{4+5}) ; the costal, sub-costal and the anterior portion of the cell C_{1+2} are distinctly yellow. The scale structure of the veins is peculiar, as there are no lateral vein scales present except toward the apices of R_1, R_2, R_3, R_{4+5}, M_1 and M_2, moreover the median scales of the veins are distinctly small. The two specimens before me show the same peculiarity in this connection.

Length : 9 mm., not including the proboscis.

North Queensland : Berner Creek, near Innisfail.

This is a very distinct species and markedly different from its congener, *M. alternans* (Westw.). It is the most striking Australian mosquito and ranks with the blue and golden *Megarhinus speciosus*, Skuse, for beauty. It was found by myself while working over a shallow rock pool, about nine feet by six feet in extent and nine inches deep, containing a large quantity of decaying vegetable matter and a large log of wood, on the side of Berner Creek ; the pool was in the shade of an overhanging tree from noon till sunset. Two pupae were secured on the occasion of my first visit to this pool, and notwithstanding minute and careful search on several succeeding days no further specimens were found. A single larval case was found, which almost certainly belongs to this species on account of its large size. It is not the larval skin of *Lutzia halifaxi* (Theo.), the larvae and pupae of which were also taken in some numbers in this pool.

Type and paratype in the Institute Collection.

Aëdes (Finlaya) mackerrasi, sp. n.

♂. *Head* covered with pale narrow-curved and black upright forked scales, vertex with yellowish upright forked ones in addition, sides covered with pale flat scales, bristles bordering the eyes black. Antennae with dusky plumes ; last two joints brownish, clothed with fairly dense short pale hairs ; nodal hairs dusky, nearly the length of the apical segment. Palpi clothed with deep black scales, second segment with a fairly broad median white-scaled band, penultimate and apical segments with white basal banding and clothed with dusky hairs, very dense on the

penultimate and the tip of the apical segment ; proboscis black, slender. Eyes black. *Thorax* reddish brown, densely clothed with pale golden narrow-curved scales, bristles pale except above the wing-roots, where they are dusky ; scutellum similar to thorax, except the posterior margin, which is dusky, posterior border bristles yellowish brown ; prothoracic lobes with pale narrow-curved scales and numerous dark bristles ; metanotum brown ; pleurae brown with patches of creamy-white, flat scales, bristles pale golden-yellow. *Wings* with a distinct violet tint, slightly longer than the abdomen, veins clothed with black scales with violet reflections ; base of the second fork-cell considerably nearer the base of the wing than that of the first fork-cell, the latter longer and narrower than the former ; anterior basal cross-vein shorter than the anterior and about twice its length from it. Halteres pale brown, clothed with small, pale, flat scales ; knobs pale. *Legs* black with a violet iridescence ; fore and mid femora white-scaled beneath, except for a narrow area of black scales apically, knees pale orange-yellow ; tibiae with short golden-yellow bristles, as also the femora ; first tarsal joint slightly more than half the length of the tibiae, first and second tarsals with white basal banding, remaining joints unbanded ; tarsal joints 1 to 3 of hind legs basally banded with white, fourth with rudimentary white basal banding, fifth unbanded ; ungues of fore and mid legs unequal, the larger with a tooth, hind ungues equal and simple. *Abdomen* clothed with violet-tinted black scales and dense lateral pale hairs ; segments 2 to 6 with white basal banding ; 7th with large white lateral patches extending to the dorsum but not meeting in the middle ; 8th with narrow white basal banding. Side-pieces black-scaled and covered with long dense, pale hairs ; appendage of claspette large and expanded in side view. Venter black-scaled, with white basal banding.

♀. Palpi black with violet iridescence, about one-seventh the length of the proboscis ; latter as in ♂. Legs as in ♂ ; ungues all equal and uniserrate. Wings with the scales denser than in the ♂, base of second fork-cell nearer the base of the wing than that of the first, the former slightly wider ; anterior basal cross-vein shorter than the anterior cross-vein and a little more than its own distance from the latter. Abdomen black, unbanded ; the segments with lateral, basal, triangular spots.

Length : 4·5 to 5·0 mm., excluding the proboscis.

NORTH QUEENSLAND : Innisfail district (*F. H. Taylor*).

Described from a series of both sexes, bred from pupae, found in a small pool of water, about half a litre, overgrown with coarse grass above a waterfall on Berner Creek.

This species is very close to *Aëdes* (*Finlaya*) *occidentalis* (Skuse), but may be distinguished by the absence of speckling with white scales on the femora and by the rudimentary white band on the fourth hind tarsal joint ; also by the large and expanded appendage of the claspette, whereas in *A.* (*Finlaya*) *occidentalis* (Skuse) it is narrow and almost uniformly tapering.

It affords me much pleasure to dedicate this species to my friend Dr. I. M. Mackerras, B.Sc.

Type ♂, allotype ♀, and a series of paratypes in the Institute Collection.

A NOTE ON *SIMULIUM BANCROFTI*, TAYLOR, WITH THE DESCRIPTION OF A NEW SPECIES OF *SIMULIUM* (DIPT.).

By Frank H. Taylor,
Australian Institute of Tropical Medicine, Townsville.

(Plate V.)

Simulium bancrofti, Taylor (Plate V, figs. 1–5).

Head: Width of the frons slightly less than half that of the whole head; antennae short, about two-thirds the width of the head; first three segments cyathiform, the first slightly broader than long, a little less than half the length, and slightly more than half the width of the third; second segment one-third longer than wide; segments 4–7 inclusive approximately the same length; the fourth a little wider than segments 5–7, which are all of about the same width; penultimate longer than 4–7 individually; apical segment moderately long and somewhat cone-shaped. Palpi five-jointed; first joint cyathiform, with an apical row of four bristles, the two outer ones longer than the second segment; the latter oblong, its sides nearly parallel, also with an apical row of bristles of about the length of the inner two on the first segment; first and second segments together half the length of the third, the latter somewhat obovate, tapering slightly distally; fourth almost pear-shaped, tapering basally, shorter than the third (11 : 14); fifth fusiform, tapering to a blunt point at both extremities and very little longer than the third, with a few scattered hairs, especially on its apex. *Legs*: fore femora and tibiae dilated; first tarsal joint tapering very slightly at its base, a little more than half the length of the tibia (27 : 46), outer edge with a dense fringe of spinules, except on its basal fifth, apex with a stout spine on its outer apical angle; base of second joint narrower than apex, lower surface with numerous spinules, especially on the distal two-thirds, apex with two stout spines, one on either side; third and fourth joints cyathiform, the former one-third longer than the latter; fourth with a deep median depression for almost half the length of the tarsus, forming the socket of the fifth; third joint with numerous spinules on its distal two-thirds and an apical row of moderately long spines, the outermost the longest; fourth joint sparsely covered with fairly long hairs, apex with four long, stout bristles, two on either side of the base of the fifth joint; the latter pear-shaped, a little more than twice the length of the fourth, with a few fairly long hairs on its distal half; claws short, almost straight, not toothed. Mid leg with the tibiae dilated, with a long, stout, external, apical spine; first tarsal joint not dilated, a fringe of spinules along its outer margin and a few scattered ones over its ventral surface; second joint with the spinules on the outer margin increasing in length and stoutness apically; third joint similar to that of fore leg and without spinules; fourth and fifth similar to those of fore leg; joints 2 to 5 distinctly hairy. Femora and tibiae of hind leg dilated, the inner apical angle of tibiae with a pronounced spine and distally spinulose; first tarsal joint not dilated, strongly spinulose on its whole length, distal lap slightly more than half the width of the apex of joint, but not reaching the dorsal incision of the second joint; dorsal edge of the second joint with a fairly deep indentation at its basal third; fifth joint slightly more slender than apical joint of the fore and mid legs. Claws of mid and hind legs as in the fore legs.

Length of wings, 2 mm. (*vix*), with the vein *Cu* with its bend placed about the apex of its middle third and very marked.

Attention has been directed to the foregoing species by Tonnoir giving certain emendations to the original description. I have therefore given the above redescription of the antennae, etc., since Tonnoir's remarks clearly cannot applv to the species

under discussion, being based on an error of identification. The figure of the antennae given by Tonnoir (p. 220, 1B) is quite unlike the correct rendering of a picture of the antennae of this species, in both the shape and the number of the segments, particularly concerning the first four and the apical segments. He also divides the apical segment, but this is not correct.

In view of the above this species cannot be retained in the genus *Austrosimulium*.

Simulium faheyi, sp. n. (Plate V, fig. 6).

Head: frons black, with scattered, short, pale, appressed pubescence; clypeus black, with similar pale pubescence. Antennae eleven-jointed; the first three segments cyathiform, pinkish-buff; first segment apparently shorter and narrower than the second, the latter with a distinct apical fringe of short black bristles; segments 4 to apex blackish, covered with pale tomentum; third segment longer than the fourth but of the same width; the fourth to eighth inclusive of the same length and width approximately; ninth narrower than eighth, penultimate narrower than the ninth; apical somewhat pear-shaped, narrower than the penultimate and about twice its length. Palpi black; third segment dilated, fairly long; fourth and fifth slender and together about the length of the third (owing to the much bent position of the palps it is impossible to give a fuller description). *Thorax*: scutum considerably humped, sooty black, densely covered with short, appressed, pale golden hairs; pleurae dull black, pteropleuron with an oblong patch of pale golden appressed hairs toward its dorsal margin. *Abdomen*: black, densely covered with short black appressed hairs, with scattered appressed pale golden ones on the last three segments. *Legs*: anterior and mid femora black, dilated, knees cream-buff; tibiae similar to those of hind legs; first tarsal black with black pubescence and a row of spinules on the inner margin, not dilated; remaining joints as in hind legs. Hind femora black, densely covered with black pubescence, strongly dilated; base of tibiae cream-buff densely covered with pale hairs on the basal half, dilated, more pronounced on the distal half, latter with dense black spinules on the ventral surface but little longer than the first tarsal joint (9 : 7); the latter not dilated, with a broad basal and apical dark ring, the apical ring the broader, remaining portion whitish, covered with short black pubescence, distal lap not quite half the width of the second joint, produced into a long thumb-like process apically and apparently as long as the second tarsal joint; remaining joints black; ungues slightly curved and with a small basal tooth. *Wings* hyaline, veins yellowish; the vein *Cu* with its bend commencing about the apex of its basal half and dipping somewhat sharply, then rising, near its apex, gently to the wing border. Halters dark, with the knobs cream-buff.

Length: 2 mm. (*circa*); of wing 2 mm.

North Queensland: Berner Creek.

Type deposited in the Collection of the Institute.

The abdomen is bent upon itself, rendering exact measurement very difficult. The above brief description is based upon a single specimen taken with the net. When further material is available a full and detailed description will be published. The insect appears to be a well marked species on account of the markings of the hind tibiae and first tarsals. Sex doubtful.

The microphotograph of the antenna of *S. faheyi* lacks the first and second segments, as they did not come away from the head in the dissection.

I have much pleasure in dedicating this species to my friends Mr. and Mrs. E. G. Fahey, with whom it was my good fortune to spend a very profitable and pleasant fortnight during September 1926.

The microphotographs were taken by myself from specimens prepared with a 5 per cent. solution of KOH without heat. The plates used were Process Panchromatic,

the exposures being made through a Wratten C filter. The illuminant was a pointolite. The objective and ocular used were a Zeiss 16 mm. apochromat and a K.2 3x respectively.

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TONNOIR, A. L. Australian Simuliidae.—Bull. Ent. Res. xv, pt. 3, 1925.

Fig. 1. *Simulium banerofti*, Taylor, head.

Fig. 2. *S. banerofti*, antenna.

Fig. 3. *S. banerofti*, middle leg.

Fig. 4. *S. banerofti*, foreleg.

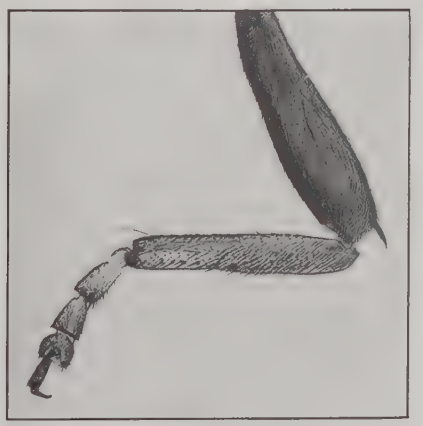

Fig. 5. *S. banerofti*, hind leg.

Fig. 6. *Simulium faheyi*, sp.n., antenna. (first two joints missing.)

THE PARASITIC HYMENOPTERA OF ECONOMIC IMPORTANCE NOTED FROM SOUTH INDIA.

By T. V. Ramakrishna Ayyar,
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Two previous lists of Parasitic Hymenoptera of economic importance have been prepared and published by the writer—one in 1919 and another in 1921 ; these included some of the more important of the economic forms then noted. During the last two or three years further work in this line was continued and additional data have been collected. In this paper an attempt is made to bring together in one incorporated list all the forms hitherto recorded from South India, at the same time revising the previous lists wherever necessary and adding recently collected data or data omitted from the two previous lists. It is believed that this revised list, with the available bionomical and synonymical notes, may be of some use for purposes of reference to those interested in this line of work. The writer takes this opportunity of expressing his thanks to the authorities of the Imperial Bureau of Entomology, London, and of the United States National Museum, Washington, for the help received from them in identifying some of the forms submitted to them, and confirming or correcting some of the identifications made at Coimbatore.

Family Braconidae.

Aphrastobracon flavipennis, Ashm. This is the insect referred to in the list of 1921 as *Megalommum* sp. Owing to the very close relationship between these two genera it was at first identified as *Megalommum*. Ashmead first described this interesting insect from specimens reared on the lac insect in Ceylon in 1895. This species has been bred in South India in some numbers from two or three kinds of Coccidae, namely, *Tachardia lacca*, Kerr, *Pulvinaria maxima*, Gr., and *Anomalococcus indicus*, Gr. It has, however, been found to be parasitic on the Noctuid caterpillar, *Eublemma scitula*, Rmbr., which is a predator on the scale-insects noted above. It has also been bred from lac material in Mysore.

Glyptomorpha (*Iphiaulax*) *smeenus*, Cam. Parasitic on Buprestid larvae (*Sphenoptera* spp.) boring into ground-nut, cotton, and pulses. Coimbatore, Bellary, etc.

Glyptomorpha (*Bracon*) *deesae*, Cam. Parasitic on stem-boring Pyralids on cholam, ragi, etc. Coimbatore. A fairly common and large species.

Glyptomorpha (*Bracon*) *nicevillei*, Bing. A parasite on stem-boring caterpillars in S. India. Noted in cane and paddy fields in North Circars, S. Kanara, etc. ; not so common in Coimbatore as *G. deesae*. A very similar insect, *Stenobracon* sp., is recorded as a parasite of the paddy stem-borer (*Schoenobius*) in Formosa, and probably *G. deesae* and *nicevillei* belong to that genus.

Iphiaulax spilocephalus, Cam. This and allied species of *Iphiaulax* are commonly found in cholam fields, and they are probably parasitic on the stem-borers. *Merinotus*, recorded in the 1921 list, is a subgenus of *Iphiaulax*, according to Szepligeti.

Ipobracon sp. Parasitic on the common Indian fruit-fly, *Dacus* (*Chaetodacus*) *cucurbitae*, on gourds. Coimbatore.

Philomacroploea basimacula, Cam. Parasitic on Danaine caterpillars on such garden plants as *Calotropis*, *Nerium*, etc. It is probably a *Chelonogastra*, Ashm.

Bathyaulax sp. Parasitic on a fruit-fly, *Bactrocera* sp., on *Alangium* fruits. Anantapur District.

* *Cp.* Bull. Ent. Res. xvii, 1926, pp. 91-98.

Campyloneurus ceylonicus, Cam. Parasitic on the grub of the *Sesbania* shoot weevil (*Alcides bubo*). Coimbatore. This insect was originally described by Cameron in the genus *Bracon*.

Microbracon lefroyi, Dudg. & Gough. Parasitic on the cotton bollworms, *Earias* and *Platyedra*, throughout India. Several colour variations have been observed in specimens reared from these and other hosts, and perhaps more than one species are concerned. The other hosts so far noted in S. India are *Adisura atkinsoni*, *Phthorimaea blapsigona* and *Crocidolomia binotalis*.

Microbracon sp. Parasitic on the brinjal stem-borer (*Euzophera*) and the cholam stem-borer (*Chilo*) in Coimbatore ; appears to be close to *Amyosoma* (*Microbracon*) *chelonis*, Vier., on *Chilo simplex* in Formosa. Fairly common in Coimbatore.

Various species of *Microbracon* have also been noted on the Zizyphus fruit-borer caterpillar (*Meridarchis scyrodes*), and on the kolinji pod gall Gelechiid (*Dactylethra candida*).

Zombrus sp. Parasitic on Cerambycid larvae boring in different plants ; noted in Malabar, N. Circars, etc. Turner has described a species of this genus (*Trichiobracon striolatus*) from Dehra Dun. *Trichiobracon*, *Acanthobracon*, *Trichodoryctes* and *Neotrimorus* are all synonyms of *Zombrus*, according to Viereck.

Clinocentrus sp. Parasitic on the paddy skipper, *Parnara mathias*. Coimbatore.

Heterogamus percurrens, Lyle. Parasitic on *Perigaea capensis* infesting safflower plants. Coimbatore.

Aleiodes sp. Parasitic on the Limacodid larva, *Contheyla rotunda*, on coconut palm. Malabar.

Troporhogas maculipennis, Cam. (?).* Parasitic on the caterpillar of the hawk-moth, *Daphnis nerii*. Coimbatore.

Chelonus or *Chelonella* spp. Species of this easily recognisable genus have been noted on the tobacco stem-borer (*Phthorimaea heliopa*), the paddy swarming caterpillar (*Spodoptera mauritia*), the groundnut leaf-miner (*Stomopteryx nerteria*), the pink bollworm (*Platyedra gossypiella*) of cotton, the tobacco caterpillar (*Prodenia litura*), and on a species of *Plusia*.

Phanerotoma sp. Parasitic on the brinjal stem-borer (*Euzophera perticella*). Coimbatore.

Phanerotoma sp. Parasitic on *Etiella zinckenella*, the caterpillars of which infest the sann hemp plant. Coimbatore.

Phanerotoma sp. Parasitic on bag-worms (PSYCHIDAE) on different plants. Coimbatore.

Apanteles prodeniae, Vier., is parasitic on *Prodenia litura*.

Apanteles taragamae, Vier., parasitises *Taragama dorsalis*.

Apanteles (*Protapanteles*) *colemani*, Vier., parasitises *Orgyia postica*.

Apanteles (*Protapanteles*) *creatonoti*, Vier., on *Creatonotus albistriga*.

Apanteles (*Protapanteles*) *papilionis*, Vier., on *Papilio demoleus*.

Apanteles (*Protapanteles*) *stauropi*, Vier., on *Stauropus alternus*.

Apanteles phycodis, Vier., on *Phycodes radiata*.

Apanteles plusiae, Vier., on *Plusia peponis*.

The above are the commoner species of this genus so far noted from South India ; they were all first recorded from Mysore.

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* Report of 5th Ent. Meeting, Pusa, 1923, p. 264, Plate xxi.

In addition to the above definitely determined species from Mysore, species of *Apanteles* have been reared in South India from larvae of *Natada nararia, Euproctis scintillans* and *fraterna, Psalis securis, Perigaea capensis, Exelastes atomosa, Platyedra gossypiella, Plusia peponis, Nephantis serinopa, Stauropus alternus, Amsacta* spp. *Parasa lepida, Parnara* sp., etc.

Apanteles (*Stenopleura*) sp. Parasitic on borers in sugar-cane, cholam and maize. Godavari and Coimbatore.

Microplitis eusirus, Lyle. A specific and effective parasite on the castor semilooper, *Achaea janata*, all over South India. (*Cp.* Jl. Bombay N.H.S. xxviii, 1921, pp. 298–300.)

Microplitis sp. Parasitic on the caterpillar of a hawk moth, *Macroglossum* sp. Coimbatore. Evidently an undescribed species.

Euagathis cryptophlebiae, Vier. Parasitic on a Eucosmid caterpillar (*Argyroploce illepida* ?). Mysore.

Disophrys sp. Parasitic on a Hypsid moth, *Hypsa ficus*, on *Ficus indicus*. Coimbatore.

Disophrys sp. Parasitic on a Lymantriid moth, *Euproctis fraterna*, on rose leaves. Madras.

Microdus sp. Parasitic on the brinjal leaf-roller Noctuid (*Eublemma olivacea*).

Cardiochiles sp. Parasitic on the paddy leaf-roller (*Cnaphalocrocis medinalis*). Ganjam.

Tropobracon luteus Cam. (?). Noted as parasitic on the paddy stemborer (*Schoenobius*). Specimens have been collected from South Kanara, the N. Circars and the Ceded Districts. This species appears to be very closely allied both to *Habrobracon*, Ashm., and to *Shirakia*, Vier.—the latter described as parasitic on *Schoenobius* in Formosa. My examples appear to be somewhat different from Cameron's type.

Austroopius sp. On the fruit-fly, *Dacus longistylus*, attacking the seed capsules of *Calotropis*, in South India.

Opius fletcheri, Silv. Parasitic on fly maggots infesting various fruits such as watermelons, *Zizyphus*, mango, guava, and Cucurbitaceae; commonly found on *Dacus* (*Chaetodacus*) *cucurbitae* throughout India.

Opius (*Diachasmimorpha*) *comperii*, Vier. On fruit-fly maggots.

Opius incisi, Silv. On *Dacus* (*Chaetodacus*) *incisus* infesting fruits of the tree, *Carissa arborea*. Coorg.

Opius (*Biosteres*) *persulcatus*, Silv. On *Dacus* (*Chaetodacus*) *incisus*. Coorg.

Opius (*Biosteres*) *compensans*, Silv. On *D.* (*Chaetodacus*) *incisus*. Coorg.

Opius (*Biosteres*) *carpomyiae*, Silv. On a fly boring into Zizyphus fruits. Coimbatore.

Meteorus arctiicida, Vier. Parasitic on Arctiid larvae. Mysore.

Meteorus sp. Parasitic on *Cirphis albistigma* on paddy. South Arcot. Evidently a new species.

Aphidius colemani, Vier. Parasitic on tobacco aphis. Bangalore.

Spathius sp. Parasitic on the shot-hole borer (*Dinoderus*) in bamboo frame-work. Coimbatore.

Asobara orientalis, Vier. Parasitic on fruit-flies.

Family Ichneumonidae.

Xanthopimpla immaculata, Morl. Parasitic on the paddy skipper, *Parnara mathias*. Palur (S. Arcot), Madras, and Coimbatore.

Xanthopimpla pedator, F. On various caterpillars in Koilpatti, S. India, and on *Chilo* in Coimbatore.

Xanthopimpla nursei, Cam. On *Chilo simplex* and allied caterpillars. All over South India.

Xanthopimpla sp. On the paddy Noctuid, *Cirphis albistigma*. Palur, S. Arcot.

Xanthopimpla punctata, F. On borer larvae. Saidapet and Samalkota.

Bassus clotho, Morl. Recorded as bred from *Plutella* larvae, but evidently this is a mistake, as these insects parasitise Syrphid larvae. Surat and Coimbatore.

Paniscus ocellaris, Th. On caterpillars of *Achaea janata* on castor. Coimbatore.

Henicospilus merdarius, Gr. On caterpillars of *Euproctis scintillans* and *E. fraterna*. Saidapet and Coimbatore.

Heniscospilus horsfieldi, Cam. On hairy caterpillars. S. India.

Heniscospilus sp. On the castor caterpillar, *Achaea janata*. Coimbatore.

Hymenobosmena sp. Parasitic on the brinjal leaf-folder (*Eublemma olivacea*) and the gingelly leaf caterpillar (*Antigastra catalaunalis*). Coimbatore.

Dioctes argenteopilosa, Cam. On the tobacco caterpillar, *Prodenia litura*. Coimbatore. It has also been recorded on *Laphygma exigua* in the Central Provinces.

Pristomerus testaceus, Morl. On the brinjal stem-borer, *Euzophera perticella*; has also been recorded on the brinjal fruit-borer, *Leucinodes orbonalis*. Attur, Chingleput.

Pristomerus euzopherae, Vier. On *Euzophera perticella*. Bangalore.

Pristomerus sp. On the Cossid, *Azygophleps scalaris*. Coimbatore. (*Cp.* Proc. 4th Ent. Meeting, Pusa.)

Ischnojoppa luteolator, F. Very common in Coimbatore and other places in S. India. It has been recorded as apparently a parasite of the paddy stem-borer, *Schoenobius*, all over India.

Microtoridea lissonota, Vier. On the cotton leaf-roller, *Sylepta derogata*. Mysore.

Zamesochorus orientalis, Vier. On *Achaea janata*. Mysore.

Mesochorus plusiephilus, Vier. A hyperparasite of *Apanteles plusiae* on *Plusia peponis*. Bangalore.

Family Evaniidae.

Evania antennalis, Westw. The common shining black species parasitizing egg-capsules of cockroaches. South India.

Superfamily Serphoidea.

Telenomus colemani, Crawf. Parasitic on eggs of a Pentatomid bug, *Dolycoris indicus*. Mysore.

Telenomus latisulcus, Crawf. From eggs of a Pentatomid, *Coptosoma cribraria*, Coimbatore; also bred from brood-cells of a carpenter bee (*Xylocopa*) in Mysore.

Hadronotus fulviventris, Crawf. From eggs of *Clavigralla*. Coimbatore.

Ceraphron sp. On *Plusia agramma*. Coimbatore.

Polygnotus sp. On the paddy gall-fly, *Pachydiplosis oryzae*. Tanjore.

Xestonotidea foersteri, Gah. From galls on grass, evidently on gall flies. Coimbatore.

Scelio spp. From eggs of grasshoppers on paddy, *Hieroglyphus banian* and *Oxya velox*. Coimbatore.

Superfamily CHALCIDOIDEA.

Chalcis argentifrons, Ashm. On a Lasiocampid caterpillar. Coimbatore.

Stomatoceras ayyari, Gah. On a Limacodid, *Parasa lepida*. Coimbatore.

Stomatoceras sulcatiscutellum, Gir. On the palm caterpillar, *Nephantis serinopa*, South India.

Goniogaster varicornis, May. From fruits of *Ficus*. Coimbatore.

Walterella temeraria, Westw. From fruits of *Ficus indicus*. Madras.

Podagrion sp. From egg-capsules of *Mantis* sp. Coimbatore.

Eurytoma parasae, Gah. On *Parasa lepida* and *Thosea* sp. Coimbatore.

Eurytoma denticoxa, Gah. From stored maize seeds—probably parasitic on some meal-worm caterpillar. Coimbatore.

Eurytoma dentipectus. Gah. On the gingelly gall-fly, *Asphondylia sesami*. Coimbatore.

Eurytoma setitibia, Gah. From galls on *Trewia*. Coimbatore.

Eurytoma chrysothrix, Waterst. Parasitic on maggots boring into bamboo shoots. Walayar Forests, South India.

Bruchophagus mellipes, Gah. Boring into *Sesbania* seeds. S. India. (Phytophagous.)

Aphycus fuscidorsum, Gah. Parasite on a scale, *Ceroplastodes cajani*, on *Dolichos lablab*. Coimbatore.

Aphycus flavus, How.? On the nim scale, *Pulvinaria maxima*. Coimbatore.

Anicetus ceylonensis, How. On *Pulvinaria maxima*. Coimbatore.

Paracopidosomopsis javae, Gir. On a Noctuid, *Plusia signata*. Coimbatore.

Encyrtus lecaniorum, Mayr. On *Lecanium nigrum*. Coimbatore. This is *Encomys lecaniorum* of the 1921 list.

Anastatus colemani, Crawf. Parasitic on eggs of a Pentatomid bug, *Degonetus serratus*. Bangalore.

Anastatus sp. On the eggs of a grasshopper, *Oxya velox*, and of a hawk-moth, *Polyptychus dentatus*. Coimbatore.

Neanastatus trochantericus, Gah. From grass galls, probably on a gall-fly. Coimbatore.

Bruchocida orientalis, Crawf. On larvae of *Bruchus chinensis*. Bangalore.

Scutellista cyanea, Mot. On *Lecanium nigrum* and *L. oleae*. Coimbatore.

Bruchobius colemani, Crawf. Bred from pods of *Cajanus indicus*, evidently parasitic on a species of *Bruchus*. Coimbatore.

Pteromalus oryzae, Cam. On the rice weevil, *Calandra oryzae*; all over India.

Eupteromalus parnarae, Gah. On the paddy Hesperiid, *Parnara mathias*. Karvetnagar.

Aplastomorpha calandrae, How. Parasitic on a beetle, *Sitodrepa*, infesting stored coriander. Madras. This is *Meraporus vandinei* of the 1921 list.

Elasmus indicus, Roh. On a scale, *Anomalococcus indicus*, Gr. Coimbatore.

Elasmus nephantidis, Roh. On the palm caterpillar, *Nephantis serinopa*. Coimbatore; found also in other places in South India.

Pediobopsis locustivora, Roh. On eggs of Tettigoniids on the edge of a *Cordia* leaf. Coimbatore.

Pleurotropis epilachnae, Roh. On grubs of a Coccinellid beetle, *Epilachna*. Coimbatore.

Pleurotropis foveolatus, Crawf. On grubs of *Epilachna*. Bangalore.

Tetrastichus ayyari, Roh. On the cholam borer, *Chilo simplex*. Coimbatore.

Tetrastichus nyemitaurus, Roh. On the cholam stem maggot. Coimbatore.

Tetrastichus okawus, Roh. Reared from cumbu grains; probably on gall-flies. Coimbatore.

Tetrastichus isaaci, Roh. From galls on *Macrina arneria*; probably on gall-flies. Coimbatore.

Tetrastichus coimbatorensis, Roh. On the cholam gall-fly. Coimbatore.

Tetrastichus colemani, Crawf. On grubs of a Cassidid beetle, *Aspidomorpha*. Bangalore.

Tetrastichus ophiusae, Crawf. On the castor Noctuid, *Achaea janata*. Mysore.

Ootetrastichus sp. On eggs of a Fulgorid (*Pundaluoya*) on cholam. Coimbatore.

Tumidiscapus oophagus, Gir. On eggs of the paddy grasshopper, *Oxya*. Coimbatore.

Euplectrus busbyi, Crawf. On a caterpillar on leaves of *Pongamia*. Coimbatore.

Euplectrus leucostomus, Roh. On a caterpillar on castor. Coimbatore.

Euplectrus euplexiae, Roh. On a Noctuid, *Perigaea capensis*. Coimbatore.

Euplectrus nyctemerae, Crawf. On the caterpillar of a Hypsid, *Nyctemera lactinia*. Bangalore.

Euryscotolinx coimbatorensis, Roh. On the lab-lab leaf-miner, *Cyphosticha coerulea*. Coimbatore.

Asympiesella indica, Gir. On the red gram leaf-roller, *Gracilaria soyella*. Coimbatore.

Cassidocida aspidomorphae, Crawf. On the grub of a Cassidid beetle, *Aspidomorpha miliaris*. Bangalore and Coimbatore.

Aneristus ceroplaste, How. (= *Coccophagus orientalis*, How.). On the black scale, *Lecanium nigrum*. Coimbatore.

Marietta leopardina, Mot. On the nim scale, *Pulvinaria maxima*. Coimbatore.

Ceratoneura indi, Gir. From shoots of *Sesbania aegyptiaca*. Coimbatore.

Ceratoneura indica, Roh. From plant galls. Coimbatore.

Syntomosphyrum indicum, Silv. On fruit-fly maggots. S. India. This parasite was collected and taken to Australia by Mr. Compere in 1907.

Paranagrus optabilis, Perk. On eggs of the cholam shoot Fulgorid (*Pundaluoya*). Coimbatore.

Family Bethylidae.

Trissomalus fulvicornis, Roh. On the caterpillar of *Argyroploce illepida*. Mysore.

HAITIAN COTTON AND THE PINK BOLLWORM.

By George N. Wolcott.

The pink bollworm of cotton in recent years has become so extensively distributed and is of such general, world-wide importance that its exceptional status in Haiti may prove to be of more than local interest.

Haiti is the western third of the island of Hispaniola, which is the second largest of the West Indies, lying between Cuba and Jamaica on the west and Porto Rico on the east. The Dominican Republic occupies the remainder of the island, and is sharply contrasted with its smaller but more populous neighbour in the language, racial origins, habits and customs of its people. Cotton is not extensively grown in the Dominican Republic; in Haiti, however, it is second only in importance to coffee. The extensive plains of the Cul-de-Sac and the Artibonite seem to be especially well adapted in soil, elevation, and climate to its growth, and here it forms the main money crop of the region.

In the arroyos of the desert region of the southern part of Santo Domingo, around Azua and Barrahona, a native wild cotton grows, of which the lint is brown in colour. At the time that herbarium and planting material was being collected by the botanists, Drs. H. D. Barker and Erik Ekman, personal examination by the writer showed no bolls infested by the pink bollworm. This may, or may not, be the original prototype of the Haitian cotton of commerce, but as will later be shown, it shares with the Haitian cotton one unusual physiological characteristic—resistance to pink bollworm attack.

The lint of Haitian cotton is for the most part white, ordinarily of surprisingly good length and quality, but in some sections, especially around Jacmel, a considerable percentage of it has the objectionable yellow or brown colour, and occasional bushes with the dark-coloured lint are to be found in cotton fields in all parts of the Republic. The pickers harvest it all indiscriminately, even though penalised by a lower price from the buyers and exporters.

Most of the commercial Haitian cotton is free-seeded; that is, the lint does not adhere to the seeds, which are smooth and polished, not fuzzy. However, one cannot make unqualified or too definite statements regarding Haitian cotton, for it presents all sorts of morphological variations, and no artificial selection for the more desirable of these characters appears ever to have been made. In some other respects it shows a surprising uniformity, especially as compared with other cottons. No matter at what season of the year the seed may be planted, the plants do not begin to produce flowers until December. Bolls begin to mature early in January, and within two months, or three months at the most, the picking season is over. The older leaves drop from the plants as the bolls mature, so that only bare stalks and empty bolls are to be seen by spring. Even the most careless of growers are apt to cut down the bushes at this time so that next year's growth will ratoon from the ground. If weather conditions are just right, a partial second crop, or rather a much delayed part of the first crop, may be matured late in the spring, but this is quite exceptional. Ordinarily only the single winter crop is produced, vegetative growth taking place throughout the rest of the year.

Agriculturally, cotton can scarcely be called a cultivated crop in Haiti. Under the most favourable conditions it grows like a weed, being self-seeded and crowding out other vegetation if given half a chance. The great bulk of the crop receives little more attention from the grower than picking and transportation to a market. It is profitable in favoured regions because of low cost of production, rather than because

of superior quality and corresponding high price. Naturally, little attention has ever been given to the control of fungous diseases or insect pests.

In the region around Gonaives particularly, because of deficient rainfall, the red spider, *Tetranychus telarius*, Linn., is apt to be abundant during the fall, but as what is considered a normal crop is ordinarily produced, the expenditure of time and money and effort in its control is never seriously considered. Scattered occurrences of the red spider elsewhere are sometimes noted, but usually opportune rains promptly eliminate the infestations.

The cotton leaf caterpillar, *Alabama argillacea*, Hübner, is another apparently serious pest, ordinarily appearing two or three, or more, times every year and entirely defoliating the plants. Yet unless it happens to occur in especially great abundance when squares and flowers are being produced, the vegetative vigour of the native cotton plants is so great that under ordinarily favourable conditions they readily outgrow the repeated defoliations and eventually produce a normal crop. Indeed some growers rather welcome the appearance of this insect, for they claim that the caterpillars automatically effect a salutary pruning of the exuberant bushes, and save them the trouble of doing it.

When no poisons are applied to the cotton leaves, extensive outbreaks of the cotton Aphid, *Aphis gossypii*, Glover, do not occur. In the few instances where the cotton has been repeatedly poisoned to control the leaf caterpillar, the Aphids appeared in enormous numbers, shortly to be succeeded by swarms of their parasitic and predacious enemies—*Aphidius, Baccha, Scymnus,* and *Chrysopa.*

Haitian cotton seems to be rather susceptible to a variety of boll-rots and diseases of the boll, or this apparent susceptibility may rather be the result of numerous wounds made by the abundance of cotton-stainer bugs, *Dysdercus andreae,* Linn. Questionable as may be the advisability and profitableness to the average grower of attempting the control of the other pests of cotton in Haiti, the results of recent experiments clearly show a great reduction in boll diseases, and of course in the number of the bugs themselves, from persistent collection during the months of December and January when they first appear on the cotton. Small cans half filled with kerosene are the only equipment required, and with labourers receiving thirty cents a day, and boys and women corrrespondingly less, the cost even for large acreages is negligible. By destroying the first stainers to appear on the cotton plants, and continuing collections until picking has commenced, the swarms of bugs which otherwise occur on the late cotton are readily eliminated.

The scale-insects, *Saissetia hemispherica*, Targioni, and especially *Hemichionaspis minor*, Maskell, sometimes become abundant on the main stem and branches of cotton. This usually occurs when the plants are allowed to become trees, and heavy infestations are largely prevented when the plants are cut close to the ground each year.

The blister mite, *Eriophyes gossypii*, Banks, seldom attacks native cotton, although apt to be common on Sea Island, Violet, and other introduced varieties.

In the region around Gonaives and St. Michel Lepidopterous larvae boring in the terminal stalks are sometimes found, but are so rare that none of the few collected were successfully reared.

In considering the status of the Arthropod pests of cotton in Haiti before the advent of the pink bollworm, it should be emphasized that none are really major pests in the sense that the boll weevil and the pink bollworm are universally admitted to be. This would seem to make it all the more surprising that the exact date of the advent of the pink bollworm (which in the summer of 1924 was determined by the writer to be present everywhere in Haiti) is unknown. Within a year of its introduction in any other country as small as is Haiti, the result of its presence would be shown in such a decrease of the crop produced that it would be apparent not only to the entomologist,

but to cotton growers, cotton buyers and exporters, and even to business men in general. Yet not only is the date of the appearance of the pink bollworm in Haiti unknown, but nobody having to do only with the native crop is even yet aware of its presence. Indeed, if one tries to demonstrate its presence in Haiti, it requires hours of search to find infested bolls of native cotton. This is so much at variance with the story of the appearance of the pink bollworm in other cotton-producing countries, is, indeed, so very extraordinary, that it is only after repeated observations extending over a period of three years that it is here reported as being unquestionably true.

The scarcity of the pink bollworm is not due to exceptional climatic conditions in Haiti, for other varieties of cotton such as Sea Island, Violet, Peruvian, and Meade, growing there are heavily infested, just as they are in other countries.

It is not, in any very large measure at least, and as might at first appear likely, due to the short crop season of the native cotton. As December to March are the only months when native cotton has bolls on which the larvae might feed, the absence of a suitable host during the remainder of the year might, and in some exceptional cases very probably does, exercise a rather considerable check on its increase. Despite the fact that native cotton is the only commercial variety successfully grown in Haiti, yet throughout the country there are scattered plants of Sea Island cotton, and of a purplish variety called "Violet." These are not restricted to the winter months for maturing bolls, and almost invariably the bolls on these plants are heavily infested. In fields of native cotton near by, or even interspersed with such plants, or near experimental plantings of Peruvian or Meade cotton, the bolls of the native cotton are practically as free from pink bollworm injury as though no heavily infested plants were near. Of course, pink bollworm can be forced to attack native cotton by destroying heavily infested bushes of the other varieties just before bolls begin to appear on the native cotton, but so long as the other varieties are present their bolls will be riddled with tunnels, while those on the adjacent native bushes will remain practically uninfested. The contrast between field after field of native cotton so lightly infested that one can only by persistent search find an average of one typically infested boll an hour, and a field of Meade cotton so heavily infested that almost as long is required to find a single uninfested boll, is too striking to be ignored. Such high resistance of the native cotton is not merely an occasional accident caused by some vagary of climate, by exceptional care in cultivation, fumigation of seed or carrying out some of the other recommendations designed to limit the depredations of the pink bollworm, but is the regular and accepted rule, and occurs without any conscious effort on the part of the persons growing the cotton.

A preliminary experiment in sending seed of the native Haitian cotton to Mexico, to determine if it would retain its immunity from the pink bollworm under a different environment in another country, was not successful, as it was received so late that frost killed the plants before they had begun to flower. It is, indeed, doubtful if Haitian cotton will ever succeed where killing frosts occur, for although it can mature a crop in six or seven months, it never in Haiti flowers before December. (The definite time of flowering and its resistance to pink bollworm are indeed more fixed and constant than any of its morphological characteristics.) A second sending of seed to Mexico, as well as others to Korea and Hawaii, have been made, but no report on the results obtained has been received. They may be more or less anticipated, however, by observations previously made in Porto Rico.* What is presumably the same variety, or one very similar to the Haitian cotton, also occurs in the "Isle of Enchantment," growing wild or by accident in dooryards. When making examinations to determine the spread of the pink bollworm in Porto Rico, ordinarily only plants of the much more common Sea Island cotton were examined, but sometimes the only available plant

* "The Distribution of the Pink Bollworm in Porto Rico." Wolcott, G. N., Circular No. 85, Insular Experiment Station, Rio Piedras, Porto Rico, pp. 3–7. San Juan, September 1923.

in a particular locality was this so-called " algodon del pais " or native cotton. The bolls collected from such plants were invariably uninfested, but no importance was attached to that fact at the time. Those examined were at the supposed outmost limits of the spread of the pink bollworm for that year, and even Sea Island bolls in such a position might be expected to be lightly infested, if at all. Moreover, the bolls of the wild cotton are by comparison so small that nobody has cultivated it in recent times since the introduction of Sea Island, and the idea of doing so would seem preposterous. Yet the bolls of these despised plants were invariably sound, so far at least as the pink bollworm was concerned, and presumably Haitian cotton, or Porto Rican " del pais " cotton, will retain its immunity in any country where climatic conditions are substantially similar to those obtaining in the West Indies.

25th February 1927,
Port-au-Prince, Haiti.

NOTES ON THE DISTRIBUTION AND HABITS OF CULICIDAE IN CENTRAL ABYSSINIA.

By Hugh Scott, M.A., Sc.D., F.E.S.,
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(Plate VI.)

The purpose of this paper is to place on record my notes on the distribution of the mosquitos obtained by myself during an Expedition to Central Abyssinia made, in company with Mr. J. Omer Cooper, from September 1926 to January 1927. We were engaged in collecting insects of many Orders and some other animals, as well as plants, so that it was not possible to devote more than a limited time to Culicidae. Nevertheless, I purposely gave rather special attention to this family and got together a series of some 103 specimens of the adult insects, belonging to 13 (or possibly 14) species. Examples of each species were pinned immediately, when freshly killed, with fine pure-silver pins, while in a few places where large numbers of one species occurred the surplus specimens were placed in spirit. No detailed investigation of the larval or pupal stages was undertaken; a few examples of these may later be forthcoming among the collection of aquatic organisms which are Mr. Omer Cooper's special province, but they are not dealt with here.

The determination of the species is entirely due to Mr. F. W. Edwards, who has also kindly supplied me with summaries of the general distribution of each species. All which it has been possible to determine exactly are referred to well-known forms, though one species (*Anopheles mauritianus*) is represented by a variety possibly new to science. The remarks as to whether or not the species of *Anopheles* have been proved susceptible to infection with the malarial parasite are based on the lists given by H. F. Carter in "The Practice of Medicine in the Tropics," edited by Byam and Archibald, vol. 1, 1921, pp. 342, 343.

Mr. Edwards has called my attention to a list of mosquitos collected by the Mission to Lake Tana in 1920 and 1921. These specimens were received at the British Museum from Dr. Grabham in June 1922. They were collected at Bahrdar Giorgis, at the southern extremity of Lake Tana; the list, and other remarks, were published in the "Report of the Mission to Lake Tana, 1920–1921," by G. W. Grabham and R. P. Black (Egyptian Ministry of Public Works, Cairo, 1925), pp. 103, 104, 118. The species are included below, with my list; two (*Anopheles mauritianus* and *Taeniorhynchus uniformis*) were also collected by me; two others, *Anopheles squamosus* and *Culex quasigelidus*, I did not find, and these raise the total number from 13 to 15 species; while the published list from Lake Tana included two other species, doubtfully referred to *Anopheles longipalpis* and *Culex fatigans*, but these Mr. Edwards has advised me to omit. It should be added that Lake Tana is some 160 miles north-west of the northernmost point where I collected mosquitos, and cannot be described as in "Central" Abyssinia; its relation to the area of my wanderings is shown in fig. 1.

No itinerary of my travels has yet appeared, though I hope later to publish a general narrative of the expedition. But all the localities at which Culicidae were collected are shown in fig. 2. For present purposes it suffices to say that Addis Ababa, the capital, was used as a base, and that these localities fell within an area extending to Djem-Djem Forest (a high forest of *Juniperus procera* and other trees), a little over 40 miles due west; to the northern extremity of Lake Zwai, nearly 65 miles almost due south; to the western outlier of the Chillálo Mountains, about 80 miles south-east; and to the Muger River Valley, about 30 miles north-west, of that city.

All these mosquito localities, moreover, lay at elevations between approximately 5,500 feet and 9,000 feet above sea-level, though my wanderings extended several thousand feet higher. So far as I am aware, no detailed information regarding the distribution of CULICIDAE within this area has hitherto appeared.

So far as I could gather from the opinions of European residents and of natives concerning the districts which I visited, Addis Ababa and the high plateaux surrounding it are regarded as free from malaria ; while the country from Doukham southwards to the Hawash River, and beyond it towards Lake Zwai, is considered malarious, as

Fig. 1. Outline map of Abyssinia; the area within which the writer collected is indicated by the dotted rectangle round Addis Ababa. Bahrdar Giorgis, where mosquitos were collected by the Lake Tana Mission, is also shown.

is also the Muger Valley. These conclusions are born of long experience and are doubtless correct ; but it should be remarked that, though Addis Ababa and its environs may be free from fever, they are not free from the presence of *Anopheles*, which may be potential carriers of fever. As the subjoined lists show, *Anopheles mauritianus*, a proved fever-carrier, was taken at (among other places) the Berga River, a mile or so beyond Addis Allem, i.e., about 30 miles due west of the capital ; while a specimen doubtfully referred to *A. transvaalensis* was collected at the British Legation, a few miles from the city itself ; this latter species does not, however, appear to be a proved carrier of malaria. Furthermore, there was a single female *Anopheles*,

which cannot be identified as I was unable to catch it, in my tent in the ravine of the Akaki River on the night of 5th December 1926; this was about seven or eight miles south-east of the city, at a point where a main caravan route in the direction of Mount Herrer and Doukham crosses the river, some miles east of the railway, and at an elevation somewhat under 8,000 feet. From the districts known to be malarious two other *Anopheles* were obtained, namely *A. gambiae* and *A. pharoensis*, both of which have been proved susceptible to infection. These, with *A. squamosus* collected by the Tana Mission, bring the list of *Anopheles* up to five species.

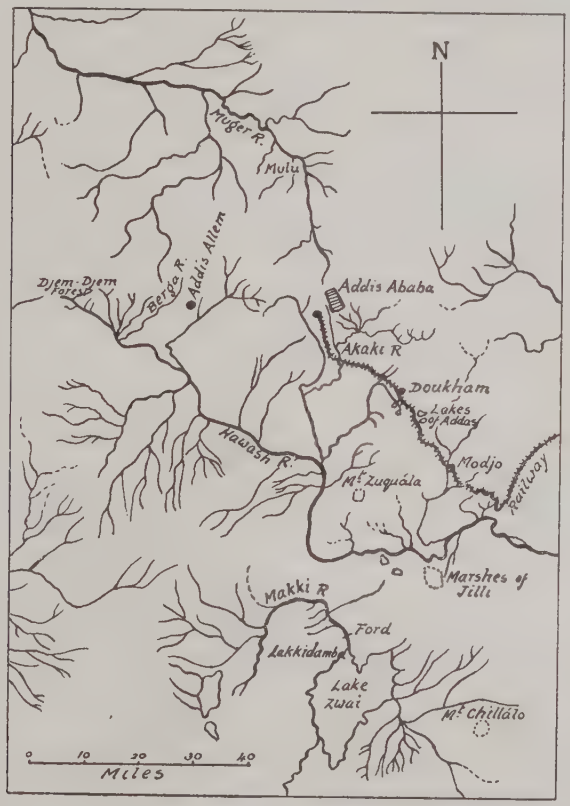

Fig. 2. Sketch-map of the district round Addis Ababa, showing the localities where mosquitos were collected in 1926–27.

Our most severe encounter with mosquitos occurred on the night of 2nd November 1926, when, partly by a mistake and partly by trickery on the part of our mule contractor, the camp was pitched at Lakkidamba, on the north-west shore of Lake Zwai.* The tents were situated on some rising grassy ground perhaps 50 feet above the level of the lake, which was here a great green marsh or lagoon (Plate vi). We had already been attacked by Culicines (*Taeniorhynchus africanus* and *T. uniformis*) since arriving at the

* My companion, Mr. Omer Cooper, thinks that I have placed Lakkidamba on the map too far north on the western side of Lake Zwai, and that the real position of the great marsh is nearer the middle of the western shore.

shores of the lake at mid-day, and on arriving in the afternoon at the camp the Culicines made a fresh onslaught, while at dusk Anophelines came in swarms, and the roof of the tent and the mosquito curtains were thickly speckled with both Culicines and Anophelines ; three species were implicated, *Anopheles pharoensis* being far the most abundant, while *Anopheles mauritianus* and *Taeniorhynchus uniformis* were both present in great numbers. The voracity of all three species was indescribable, and a horrible night followed for all the members of the caravan. The experience of travellers at Lake Zwai has varied very much, according to the particular place and season at which they have touched the lake. We were regarded as going there at the worst season, when the swamps are beginning to dry up after the rains—and, in 1926, after a season of exceptionally prolonged and heavy rains. On the morning (3rd November) following the experience above described the mosquitos recommenced their attack while we were dressing, and I packed outside the tent in the bright sunlight, as the *Anopheles* were less aggressive there than in the shade. Subsequently, however, I found an *Anopheles* trying to bite my hand in the full sunlight at 10.30 a.m., but crushed the insect so that it was indeterminable as to species. My colleague also went down to the edge of the marsh to collect water-insects before 11 a.m., and found that mosquitos rose in clouds to attack him, *Anopheles* being among the aggressors. [The data subjoined include, under *A. gambiae*, two other records of an *Anopheles* attempting to bite in the morning.] By the following night (3rd November) we had moved round more to the north of the lake, crossing the Makki River not far above the point where it flows into the lake, and we camped again in a swampy place (Gonadamba),* but much further from the lake-shore. We were here again attacked by both Culicines and *Anopheles*, but they were much less numerous than at the preceding camping-ground.

My companion and myself both escaped malaria throughout our journey. We were, of course, provided with nets and other preventives and, following advice, we took 5 grains of quinine night and morning while in the malarious tracts and for several days before and after passing through those districts. Concerning the incidence of malaria among the personnel of the caravan it is difficult to write : nearly all the men had had fever previously to entering our service, and several of them suffered from relapses even when in places free from endemic malaria. When we went south to Lake Zwai, out of eighteen men only about three declared that they had never suffered from fever, and one of these three (my personal servant) developed an attack on 16th November, while we were camped at 9,000 feet in the forests of Mount Chillálo, far from *Anopheles*. From this time onwards he suffered from recurring attacks, sometimes severe, for some weeks, till they gradually diminished under treatment. The first attack occurred 18 days after entering the malarious district at the Hawash River on 29th October, and 14 days after the bad experience on the shores of Lake Zwai. The evidence is somewhat contradictory, for though the man himself averred that he had never previously suffered from fever, an older Abyssinian in Addis Ababa, who knew him and brought him into my employ, denied that this was so. I have little doubt, however, that the man himself was right, and that he contracted the disease on the journey to Lake Zwai, since he had previously shown no signs of it during eleven weeks in which he had been in my service.

A word may be added about some places outside the area of systematic collecting. Halts for the night are made on the rail journey from the coast to Addis Ababa at Dire Dawa, some 4,000 feet above sea-level, and the Hawash rest-house, the elevation of which is some hundreds of feet less. These places are regarded as not free from infection, especially in the wet season, and mosquito nets are accordingly provided As regards my own experience : on the outward journey, in the rainy season, I spent

* " Lakkidamba " and " Gonadamba " do not appear on any map that I have seen. The words are spelt phonetically from names given me by our interpreter, who got them from the local peasantry.

the night of 1st September 1926 at the Hotel Bollolakos, Dire Dawa, but neither saw nor heard any sign of mosquitos. On the following night there was a single *Anopheles*, which I failed to catch, inside my mosquito-net at Hawash. On the return journey, in the height of the dry season, no mosquitos were in evidence either at Hawash on the night of 19th January 1927, or at Dire Dawa on the nights of 20th and 27th January. Between the two latter dates a visit was paid to Harar and on the route from Dire Dawa to that city, and *vice versa*, I slept at the inn at Lake Haramaiya on 21st and 26th January. This is at about 6,600 feet above sea-level, and precautions are considered necessary, in the rains at any rate. The inn is managed by Abyssinians, and the window of my room had calico nailed across it, while the mosquito-curtains of the bed were also of calico, not gauze (in the latter case I substituted my own portable net and used it instead of the arrangement provided). The only Culicid that I saw there was a single male of some species (it was not captured) on the night of 21st January. This was, however, as before remarked, in about the driest season of the year.

The Lake Tana Mission reported (*l.c.*) that Bahrdar Giorgis, at the outlet of the lake, has too many marshes near it to be healthy, yet there were relatively few mosquitos in July and August and the health of the camp was good till nearly the end of September. After that the mosquitos increased and there was a considerable amount of fever in October and November. Its incidence was quite as great among Abyssinians employed by the Mission, but whose homes were really in higher parts of the plateaux, as among men from the Sudan. Other parties of men who had come, respectively, from Addis Ababa during the rains, and up from Gallabat on the Sudanese frontier, also suffered severely : but this was attributed, in the latter case, to sickness contracted in the low country traversed during the journey.

Anopheles gambiae, Giles (*costalis*, Theobald).

Loc. Doukham, circa 6,500–7,000 feet, 19.x.1926, 1 ♀ (trying to bite at 8.30 a.m. in tent by slow-running stream near the station). Muger River, circa 5,500 feet, 27.xii.1926, 1 ♀ (trying to bite in the tent at 7 a.m.) ; the river was low at that season, and running swiftly over stones, but there were some stagnant pools in the dry parts of the river-bed, close under the steep earthen banks, not far away.

Distribution. The whole Ethiopian Region.

Listed among the species in which infection of the salivary glands with sporozoites of the malarial parasite has been observed in nature (*op. cit supra*).

Anopheles mauritianus, Grandpré, var.

Several varieties of this wide-spread species are known, and in the collection at present under review it is represented by a form which, as I am told by Mr Edwards, may prove to be a new variety or subspecies.

Loc. Berga River, a few miles beyond Addis Allem (nearly 30 miles due west of Addis Ababa), circa 7,500 feet, 19.ix.1926, 4 ♀ (taken in tent, but not recorded as biting). Lakkidamba, edge of swamp on north-west shore of Lake Zwai, circa 5,500 feet, 2.xi.1926, 8 ♀ (a sample from among many, biting viciously ; see remarks above). This was also one of the species collected at Bahrdar Giorgis, at the Southern extremity of Lake Tana, by the Mission of 1920–1921.

Distribution. All the Ethiopian Region, Madagascar and Egypt.

Listed among the species in which infection of the salivary glands with sporozoites of the malarial parasite has been observed in nature (*op. cit. supra*).

Anopheles pharoensis, Theobald.

Loc. Camp by ford over the Makki River, north-west of Lake Zwai, between 5,500 and 6,000 feet, 1.xi.1926, 1 ♀ (in tent at evening). Lakkidamba, edge of swamp

on north-west shore of Lake Zwai, circa 5,500 feet, 2.xi.1927, 47 ♀ (a sample from among many, biting viciously ; see remarks above. Most of the specimens were preserved in spirit).

The Makki River, at the point where the specimen first listed was taken, is a fairly deep, muddy river of considerable size, flowing swiftly between vertical earthen banks some 20 feet high, and its current is unbroken by rocks ; it is unlikely that any mosquito could have bred in the river and more probable that the breeding-place was some small collection of water in the narrow but dense belt of forest along either bank.

Distribution. Egypt, and throughout the East side of Africa to the Transvaal ; also known from the Katanga District of the Congo.

Listed among the species which have not been found naturally infected with malaria, but have proved susceptible to experimental infection (*op. cit. supra*).

Anopheles transvaalensis, Carter (?).

A single ♂ is doubtfully referred to this species by Mr. Edwards. It came to light in my tent in the field of the British Legation at Addis Ababa, circa 8,000 feet, 16.x.1926, a brilliant moonlight night after a bright, windy day.

It may be added, in case the specimen is actually an example of *A. transvaalensis*, that that species is known throughout East Africa, and according to the lists here quoted (*op. cit. supra*), has not hitherto been proved susceptible to infection with malaria either in nature or by experiment.

Anopheles squamosus, Theobald.

I did not meet with this species, but examples were collected at Bahrdar Giorgis by the Mission to Lake Tana of 1920–1921. It is widely spread in the Ethiopian Region and known also from Madagascar. It does not appear in the lists cited (*op. cit. supra*) as having been proved susceptible to infection with malaria either under natural or under experimental conditions.

Culex andersoni, Edwards.

Loc. Addis Ababa, circa 8,000 feet, 7.i.1927, 1 ♂ (in the Imperial Hotel). Mulu, above the Muger Valley, circa 8,000 feet, 19–21.xii.1926, 1 ♂.

Distribution. Previously known from Kenya and the Katanga district of the Congo.

Culex pipiens, L.

Loc. Doukham, circa 6,500–7,000 feet, 19.x.1926, 1 ♂ (in tent by slow-running stream near the station).

Distribution. Palaearctic and Nearctic Regions, Argentina, East and South Africa, and Madagascar.

Culex quasigelidus, Theobald.

Not met with by me, but examples were collected at Bahrdar Giorgis by the Lake Tana Mission of 1920–1921. Widely spread in the Ethiopian Region, and occurring in Madagascar.

Culex theileri, Theobald.

Loc. Mount Zukwála, over 9,000 feet, 24.x.1926, 4 ♀, biting in tent at evening (the temperature was low, and later in the same night a thermometer, hung on the end of a case about 9 inches above the ground, but protected to some extent by the

outer fly of the tent, registered a minimum of 43° F.) ; our camp was situated on a low part of the crater rim, and these gnats may have bred in the lake lying in the crater one or two hundred feet below. Hora Harsadi (water strongly alkaline), Lakes of Addas, some 25 miles south-east of Addis Ababa, circa 7,000 feet, 3.xii.1926, 1 ♀, in tent.

Distribution. Mediterranean countries, and all the Eastern side of Africa as far south as the Cape.

Culex vansomereni, Edwards.

Loc. Berga River, a few miles beyond Addis Allem (nearly 30 miles due west of Addis Ababa), circa 7,500 feet, 19.ix.1926, 3 ♀ (taken in tent, but not recorded as biting ; these examples are doubtfully referred to this species by Mr. Edwards, because females taken alone are not nameable with absolute certainty). Djem-Djem Forest, circa 8,000 feet, 1.x.1926, 1 ♂ (taken in house). Addis Ababa, circa 8,000 feet, 16.x.1926, 1 ♂, 1 ♀ ; these came to light in my tent in the field at the British Legation, on a bright moonlight night after a fine, windy day.

Distribution. Previously known from Kenya.

Culex sp. or spp.

1 ♀, indeterminable, from Djem-Djem Forest, circa 9,000 feet, 1.x.1926. 1 ♀, indeterminable, from Lakkidamba, the swamp on the north-west shore of Lake Zwai, circa 5,500 feet, 2.xi.1926.

Aëdes (Aëdimorphus) dentatus, Theobald (?).

Four female examples are referred to this species by Mr. Edwards with some reservation, since it is not possible to determine them with complete certainty in the absence of the male sex. They were taken in the forest of Mount Chillálo, circa 9,000 feet, 14.xi.1926.

A. dentatus is widely distributed in Eastern Africa and was previously known from Kenya to the Transvaal.

Aëdes quasiunivittatus, Theobald.

Loc. Djem-Djem Forest, circa 9,000 feet, 1.x.1926, 2 ♂, 5 ♀. Mulu, above the Muger River Valley, circa 8,000 feet, 19–21.xii.1926, 1 ♀.

Distribution. Previously known from Kenya and Natal.

Taeniorhynchus (Mansonioides) africanus, Theobald.

Loc. North-west shore of Lake Zwai, circa 5,500 feet, 2.xi.1926, 2 ♀ ; biting at midday.

Distribution. The whole Ethiopian Region.

Taeniorhynchus (Mansonioides) uniformis, Theobald.

Loc. North-west shore of Lake Zwai, circa 5,500 feet, 2.xi.1926, 3 ♀ (biting at midday), Lakkidamba, edge of swamp on the shores of Lake Zwai, a few miles south of the place just mentioned, 7 ♀ (a sample from among many, biting viciously in the tent at night, 2.xi.1926 ; see remarks above). Camp above the marshes of Jilli (a few miles south of the Hawash River), circa 6,000 feet, 30.xi.1926, 1 ♀. This species was also taken at Bahrdar Giorgis by the Lake Tana Mission of 1920–1921.

Distribution. Ethiopian and Oriental Regions and part of the Australian Region.

This insect may be concerned in the spread of filariasis (see " The Practice of Medicine in the Tropics," cited above, vol. i, p. 360).

Swamp at Lakkidamba, north-west shore of Lake Zwai; the home of great numbers of *Anopheles pharoensis*, *A. mauritianus* and *Taeniorhynchus uniformis*.

(Photograph by J. Omer Cooper).

ON THE EFFECTS OF EXPOSURE TO RAISED TEMPERATURES UPON THE LARVAE OF CERTAIN BRITISH MOSQUITOS.

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While our knowledge of the effects of variation of the physical conditions of the environment upon mosquitos is, in some directions, fairly satisfactory, in the case of the effects of variation of temperature there is lamentably little known. So far as a fairly complete survey of the literature dealing with mosquitos has revealed, there is only one paper specifically dealing with this matter, by Macfie (1920), although incidental observations have been recorded by other workers. This present paper is an outcome of an attempt to fill, to a slight degree, this lacuna in our knowledge. The investigations were carried out while the writer was attached to the Department of Zoology at the University College of North Wales, Bangor, and he has to express his thanks to Dr. C. L. Walton, Adviser in Agricultural Zoology, Department of Agriculture, Bangor, for allowing him to carry out the experiments in the Agricultural Zoology Laboratory.

The technique employed by Macfie was an exceedingly simple one, and, in order to render possible a comparison of his results with those detailed in this paper, it has been followed in the present investigations. The apparatus consists of a large water-bath, the temperature of which can be kept fairly constant for a short period; the writer was able to do this without any thermostatic regulator by standing the bath above a screened gas-flame, the height of which could be regulated. The larvae to be experimented upon are placed in a small glass beaker or capsule floating in the water-bath, and filled before each experiment with water from it; in the water in this beaker is immersed the bulb of a thermometer. The larvae are collected in a watch-glass, and as far as possible freed from water; they are then washed into the beaker with water taken from it in a capillary pipette. At the same time a stop-clock is started.

Macfie's experiments were conducted with *Aëdes argenteus* (*Stegomyia fasciata*), a species which has many advantages over those used in the present investigations in that it can easily be reared in the laboratory. He was able to test the effects of exposure by breeding from the surviving insects; since this could not be done with the species experimented on by the writer, it was decided to take an arbitrary limit of survival, which was fixed at ten days, this period being shorter than the survival limit of untreated larvae kept in tap-water.

When larvae were introduced into water above what may be called the minimum affecting temperature (that is, the degree of temperature below which no disturbance to the larvae could be detected) they at once commenced to wriggle violently; after a short interval some or all became quiescent, only moving when touched, and finally became quite inert, showing no response to stimulus.

After the experiment, the water containing the larvae was poured from the capsule into a beaker. In most of the experiments the larvae were exposed to the effects of heat for 5 minutes, but in a few cases (indicated in the tables by an asterisk affixed to the number of the experiment) the exposure was for a longer period.

During these experiments, which were conducted in the early summer of 1926, it was not possible to obtain sufficient pupae to carry out a long series of observations but such as were made support Macfie's observations in the case of *A. argenteus*, that the pupa can withstand sudden exposure to a higher temperature better than can the larva ; but it would seem that *Aëdes detritus* is an exception to this rule. The writer hopes to complete the observations on the pupae at a later date, as also investigations on the effects of exposure to reduced temperatures.

I. Effects of Exposure to Raised Temperatures on the Larvae of *Anopheles bifurcatus.*

Below a temperature of 31° C. the larvae do not seem to be affected by heat. Between this temperature and 36° C., a varying number did not survive an exposure of 5 minutes. Temperatures of 37° C. and above killed all the larvae. An exposure of one hour to a temperature of 35° C. resulted in all the larvae being killed (see Table V).

Buxton (1924) has recorded that in Palestine the larvae of this species breed mainly in " cold waters, such as those of cisterns, caves, etc., and that it can only invade the open waters in winter . . . or when they are very heavily shaded. . . ." He continues : " Our knowledge of temperature conditions in open and covered waters is very inadequate. For the benefit of future workers I put it on record that the temperature of a cistern varies 1–2° C. daily in summer, and that we have never had a reading above 21° C. . . . I have taken very few readings in open waters, but shallows in the marsh at Beisan reach 35–38° C. in the middle of a summer's day." The experiments here recorded would seem to afford an explanation of these observations ; but it is desirable that they should be repeated on larvae from Palestine.

TABLE I.

Effect of Heat on Larvae of Anopheles bifurcatus. *Larvae exposed to raised temperature for 5 minutes, except when marked *.*

Expt.	No. of larvae.	Temp. ° C.	Condition of larvae. After 5 mins.	Condition of larvae. After 24 hrs.	Results and Remarks.
A	10	42	All inert	All dead ...	All died.
B	7	42–44	All inert	All dead ...	All died.
C	10	37	All inert	All dead ...	All died.
D	10	33	5 inert, 5 much affected	3 dead ...	One pupa 24 hrs., one 5th day ; remaining larvae survived.
E*	8	32	2 slightly affected ...	Revived ...	Time 20 mins. Four pupated, two of which died. Remaining larvae survived.
F	10	34	All affected, none inert...	One dead, all sluggish.	All survived, 3 pupating between 3rd and 7th days.
G	10	32	Very slightly affected ...	Revived ...	Up to 10th day 7 pupated, of which 3 emerged. No deaths.
H	10	31	None affected	—	No deaths up to 10th day.
I	10	33	2 inert	1 dead ...	4 larvae and 3 pupae living on 10th day.

II. Effect on the Larvae of *Aëdes detritus.*

Below a temperature of 37° C. the larvae are not affected ; at temperatures of 44° C. and upwards all become inert, and none revive. Larvae of this species all died when exposed to a temperature of 35° C. for one hour.

As has been mentioned above, the pupae of *A. detritus* succumb at a slightly lower temperature than do the larvae, contrary to the general rule. While the minimum temperature is the same (37°), none recovered after 5 minutes' exposure to temperatures above 42° C.

TABLE II.

Effect of Heat on Larvae of Aëdes detritus. *Larvae exposed to raised temperature for 5 minutes, except when marked *.*

Expt.	No. of larvae.	Temp. ° C.	Condition of larvae. After 5 mins.	Condition of larvae. After 24 hrs.	Results and Remarks.
A	10	40	All at bottom, three moving slightly, rest inert.	All sluggish ...	One alive, 72 hours ; all died.
B	7	41	All pract. inert	5 revived ...	3 alive, 72 hrs. ; all died.
C	8	42	All save 2 inert.... ...	2 revived ...	All dead, 72 hrs.
D	10	45	All inert	All dead ...	All died.
E	10	44	All but 1 inert	All dead ...	All died.
F*	10	39	All but 2 inert	Recovered ...	Time 15 mins. ; 9 survived to 10th day.
G	10	37	None noticeably affected	—	8 survived to 10th day.
H	10	38	None inert, but markedly affected.	Recovered ...	8 survived to 10th day.
I	10	39	Very slight movement ...	Recovered ...	8 survived.
J	10	36	No effect	—	One died on 9th day.
K	10	35	No effect	—	One died 7th, one died 9th day.

III. Effect on the Larvae of *Theobaldia annulata.*

Larvae of this species are unaffected by temperatures below 34° C. None survived exposure to temperatures of 37° C. and over. Larvae exposed to a temperature of 35° C. for one hour all died.

TABLE III.

Effect of Heat on Larvae of Theobaldia annulata. *Larvae exposed to raised temperature for 5 minutes.*

Expt.	No. of larvae.	Temp. ° C.	Condition of larvae. After 5 mins.	Condition of larvae. After 24 hours.	Results and Remarks.
A	5	41	All inert	All dead ...	All died.
B	5	39	Greatly distressed ...	All dead ...	All died.
C	5	37	One inert, rest much distressed.	One alive ...	Died 3rd day.
D	4	35	Unaffected	—	Two died by 3rd day.
E	5	36	One much distressed, rest inert.	All dead	All died.
F	5	38	All inert	All dead ...	All died.
G	5	37	All inert	All dead ...	All died.
H	5	34	No effect	—	Two pupae surviving 6th day and onwards.

IV. Effect on the Larvae of *Culex pipiens.*

The larvae are unaffected at temperatures below 36° C., while none survived at 40–41° C.

TABLE IV.

Effect of Heat on Larvae of Culex pipiens. *Larvae exposed to raised temperatures for 5 minutes.*

Expt.	No. of larvae.	Temp. ° C.	Condition of larvae. After 5 mins.	Condition of larvae. After 24 hours.	Results and Remarks.
A	10	35	No effect	—	6 survived.
B	8	37	Markedly affected ...	Recovered ...	7 survived.
C	10	39	Very markedly affected	One dead, one accidentally killed.	8 survived.
D	10	40	All inert	4 revived ...	3 survived.
E	10	40–41	All inert	2 revived ...	One survived.
F	10	43	All inert	All dead ...	All died.
G	10	41–42	All inert	All dead ...	All died.
H	10	36	No effect	One dead ...	9 survived.
I	9	38	Almost inert	Revived ...	One died 2nd day, rest survived.

TABLE V.

Effect of Heat on Mosquito Larvae. Exposure to raised temperatures for periods of 1 hour and upwards.

Expt.	Species.	Time in hours.	Temp. ° C.	No. of larvae.	Final Result.
A	*A. bifurcatus*	1	35	10	All died.
B	,, ,,	1	32	10	Rather sluggish at 24 hrs.; all survived; 3 pupated, males emerging.
C	,, ,,	2½	30–31	10	One pupated; 7 larvae alive 10th day.
D	*A. detritus*	1	37	10	All died.
E	,, ,,	1	35	10	8 survived to 7th day, 5 to 10th day.
F	,, ,,	3	32–33	10	4 survived to 19th day.
G	*T. annulata*	1	35	5	All died.

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NOTES ON THE FOOD-PLANTS AND HABITS OF SOME SOUTHERN NIGERIAN INSECTS.

By F. D. Golding, M.A., F.E.S.

The object of the present paper is to place on record a number of observations made by the writer in the Ibadan district of Southern Nigeria in the years 1922 to 1925, in the hope that they may be of some interest to other workers in Africa.

The writer wishes to acknowledge his indebtedness to Dr. G. A. K. Marshall and the specialists of the Department of Entomology in the British Museum for identifying the insects mentioned, and to Dr. A. W. Hill, Director of the Royal Botanic Gardens, for determining the majority of the plants.

LEPIDOPTERA.

Name.	Food-plants.	Part attacked.	Month of appearance.	Remarks.
NYMPHALIDAE.				
Leucosticha daedalus, F.	*Gossypium peruvianum.*	Leaves ...	August.	
HESPERIIDAE.				
Tagiades flesus, F.	*Dioscorea* sp. ...	,, ...	,,	
SYNTOMIDAE.				
Euchromia lethe, F.	*Pergularia extensa*...	,, ...	November.	
ARCTIIDAE.				
Diacrisia lutescens, Wlk.	*Dioscorea* sp. ...	,, ...	June.	
Diacrisia occidens, Roths.	*Dolichos* sp. ...	,, ...	,,	
	Mucuna sp. ...	,, ...	August.	
Utetheisa pulchella, L.	*Crotalaria retusa* ...	Buds ...	October.	
AGARISTIDAE.				
Metagarista maenas, H.S.	*Dioscorea* sp. ...	Leaves ...	August.	
HYPSIDAE.				
Argina amanda, Bdv.	*Crotalaria retusa* ...	Leaves and buds.	October.	
NOCTUIDAE.				
Xanthodes graelsii, Feisth.	*Gossypium* sp. ...	Leaves ...	April.	
Lacera alope, Stoll.	*Haematoxylon campechianum.*	,, ...	October.	
LYMANTRIIDAE.				
Orgyia niobe, Weym.	*Hibiscus esculentus*	,, ...	August.	
Orgyia gonophora, Holl.	*Hibiscus rostellatus*	,, ...	June	Larval stage, 20 days.
SPHINGIDAE.				
Deilephila nerii, L.	*Funtumia elastica* ...	,, ...	February.	
Polyptychus digitatus, Dew.	*Cordia milleni* ...	,, ...	April.	
Hippotion osiris, Dalm.	*Boerhaavia diffusa*...	,, ...	October.	
NOTODONTIDAE.				
Anthena simplex, Wlk.	*Mucuna urens* ...	,, ...	October.	
LIMACODIDAE.				
Parasa euchlora, Karsch.	*Spondias lutea* ...	,, ...	July, August.	
COSSIDAE.				
Engyophlebus myrmeleon, Feld.	*Bridelia micrantha*...	Branch ...	March	Larva boring in branch.
TORTRICIDAE.				
Crocidosema plebeiana, Z.	*Abutilon zanzibaricum*	Unripe fruit	June.	

RHYNCHOTA.

Name.	Food-plants.	Part attacked.	Month of appearance.	Remarks.
PENTATOMIDAE.				
Coptosoma marginella, Dall.	*Desmodium mauritianum*	Stem & fruit	Apr., May, June, Sept.	Only adults seen.
	Crotalaria retusa	Stem ...	June, Sept. ...	,, ,, ,,
	Cajanus indicus ...	,, ...	June, July ...	,, ,, ,,
	Dolichos sp. ...	,, ...	August ...	,, ,, ,,
	Gliricidia sp. ...	,, ...	Apr., Aug., Sept.	,, ,, ,,
Hotea subfasciata, Westw.	*Sida carpinifolia* ...	Fruit ...	Apr. to Oct. ...	Nymphs seen in June & Aug. only.
	Sida rhombifolia ...	,, ...	Aug., Oct. ...	Adult in Aug. ; nymph in Oct.
	Hibiscus vitifolius ...	,, ...	July	Adults & eggs on ripe fruit.
	Urena lobata ...	,, ...	August ...	One adult.
	Gossypium hirsutum	?	December ...	One adult, not feeding.
Agaeus pavimentatus, Dist.	*Cordia milleni* ...	?	May	Several adults, not feeding.
Caura pugillator, F.	*Citrus aurantium* ...	Shoots ...	April	Many adults.
Aspavia armigera, F.	*Gossypium hirsutum*	Green bolls	Sept., Oct. ...	Adults numerous, only one seen feeding
	Gossypium peruvianum.	?	Oct.	Not feeding.
	Desmodium mauritianum.	Green fruit	Sept.	One adult.
	Unidentified reed & grass.	Seeds in each case.	Aug.	Only adults seen.
COREIDAE.				
Anoplocnemis curvipes, F.	*Dolichos* sp. ...	Shoots ...	May, Oct., Dec.	Only adults seen.
	Hibiscus esculentus	Buds & stem	Oct., Nov. ...	Adults & nymphs.
Anoplocnemis testator, F.	*Paullinia pinnata* ...	Midrib of leaf	May, June ...	Adults & nymphs.
	Haematoxylon campechianum.	Shoot ...	May	One adult.
	Indigofera sp. ...	Young shoots	May	Several adults.
Homoeocerus pallens, F.	*Albizzia fastigiata* ...	Shoots ...	May, June, Aug., Sept., Oct.	Nymphs seen in June, Sept., Oct.
	Gossypium hirsutum	?	Aug., Sept., Oct.	Not feeding ; one egg & three nymphs seen on leaf in Aug.
Leptoglossus membranaceus, F.	*Momordica charantia*	Fruit ...	May, July, Oct., Dec.	Nymphs seen in May, July, & Dec.
	Momordica foetida...	,, ...	Aug.	Two adults only.
	Gossypium peruvianum.	?	Oct.	Nymphs, not feeding.
Cletus fuscescens, Wlk.	*Amarantus caudatus*	Flower spikes.	May, July, Sept.	Adults ' in coitu ' in July & Sept.
Clavigralla gibbosa, Spin.	*Dolichos* sp. ...	Shoots & pods.	Jan.	Female laid 56 eggs, on two pods in laboratory ; eggs hatched in 4 days ; 1st instar 2 days ; 2nd, 4 days ; 3rd, 4 days ; nymphs died.
Riptortus tenuicornis, Dall.	*Desmodium mauritianum*	Brown pods	May, July, Aug., Sept.	Nymphs seen in May & Sept. ; closely resemble ants in early instars.
	Cassia occidentalis...	Pods ...	Sept.	Adults and one nymph
	Canavalia sp. ...	Pods ...	Aug.	Many adults.
	Citrus aurantium ...	Shoots ...	April	Several adults.
	Bixa orellana ...	?	May	Adults, not feeding.
	Cacao theobroma ...	?	April	Many adults, not feeding.
	" Pitanga cherry "	Fruit ...	May	Many adults.

RHYNCHOTA—*Continued.*

Name.	Food-plants.	Part attacked.	Month of appearance.	Remarks.
COREIDAE—*Cont.*				
Serinetha nigrofasciata, Dist.	*Paullinia pinnata* ...	Fruit ...	Apr., May, June, Aug.	Nymphs seen in each month; adult seen on cotton & okra, not feeding.
Cossutia stâli, Sign.	*Bridelia micrantha*...	Shoots ...	Apr., May, Aug.	Only adults seen.
Cossutia flaveola, Dru.	*Bridelia micrantha*...	,, ...	July	,, ,, ,,
LYGAEIDAE.				
Oncopeltus famelicus, F.	*Pouzolzia guincensis*	Shoots ...	Aug., Sept. ...	Adults & nymphs.
	Pergularia extensa	,, ...	Oct.	Only adults seen.
	Mucuna urens ...	,, ...	Sept.	Adults & many nymphs.
	Triumfetta rhomboidea	,, ...	Aug.	Adults & nymphs.
	Gossypium hirsutum	?	Aug., Sept. ...	Adults, not feeding.
Lygaeus festivus, Thunb.	*Physalis minima* ...	Fruit ...	May	Only adults seen.
Oxycarenus gossypinus, Dist.	*Sida carpinofolia* ...	Buds & fruit	June, Aug., Sept.	Only adults seen.
	Hibiscus vitifolius ...	Fruit ? ...	Aug.	One adult on fruit, not feeding.
	Hibiscus esculentus	,, ...	Aug.	,, ,, ,,
Dieuches armipes, F.	*Momordica foetida* ...	Fruit ...	Aug.	One adult.
	Cotton-seed traps ...		March to July...	Nymphs seen in May & July.
PYRRHOCORIDAE.				
Physopelta analis, Sign.	*Mallotus oppositifolius.*	Fruit ...	July, Sept. ...	Nymph seen in Sept.
Physopelta festiva, F.	,, ,,	,, ...	Oct.	Only adults seen.
Dermatinus tartareus, St.	*Citrus aurantium* ...	Ripe fruit on ground	July	,, ,, ,,
	Psidium guava ...	,, ,,	July, Aug. ...	,, ,, ,,
	Cotton-seed traps ...		June-Aug. ...	Numerous adults.
Delacampius aethiopicus, Dist.	*Sida carpinifolia* ...	Buds & fruit	Apr., May, July, Aug., Sept., Oct.	Adults seen.
	Cotton-seed traps ...		July	11 adults taken.
CERCOPIDAE.				
Ptyelus grossus, F.	*Dioscorea* sp. ...	Shoots ...	July	Many adults & nymphs
	Abutilon zanzibaricum	?	Oct.	Several newly-emerged adults seen on leaves.
JASSIDAE.				
Tettigoniella nigrinervis, St.	*Hibiscus rostellatus*	Leaves ...	May, Sept., Oct.	Only adults seen.
	Triumfetta rhomboidea	,, ...	Aug.	,, ,, ,,
PSYLLIDAE.				
Phytolyma lata, Wlk.	*Chlorophora excelsa*	Young leaves	May, Aug., Sept., Oct.	Forms galls on leaves. Adults emerged in May & Oct.

COLEOPTERA.

Name.	Food-plants.	Part attacked.	Month of appearance.	Remarks.
DYNASTIDAE.				
Oryctes owariensis, P. de B.	*Elaeis guineensis* ...	Rotten trunk.	May	35 adults, 2 pupae and many larvae seen in decayed oil palm.

COLEOPTERA—*Continued.*

Name.	Food-plants.	Part attacked.	Month of appearance.	Remarks.
CETONIIDAE.				
Pachnoda cordata, Drury.	*Gossypium* sp. ...	Flowers & greenbolls	March & Oct. ...	Adults.
	Haematoxylon campechianum	Shoots ...	April & Sept. ...	,,
	Vernonia tenoreana	Flower ...	Oct.	,,
Pachnoda marginella, F.	*Elaeis guineensis* ...	Decayed trunk.	May	Two larvae found in trunk, adults emerged in early June.
	Mangifera indica ...	Flowers ...	Sept.	Adults.
Diplognatha gagates, Forst.	*Gossypium hirsutum*	Green bolls	Dec., Jan. ...	,,
	Abutilon zanzibaricum	Green fruit	May	Adult.
	Haematoxylon campechianum.	Shoot ...	May	,,
	Vernonia tenoreana	Stem ...	Aug.	,,
Glycyphana sanguinolenta, Oliv.	*Haematoxylon campechianum*	Shoots ...	Apr., May, July	Adults.
	Zea mais	Male flowers	May	,,
	Elaeis guineensis ...	Decayed trunk.	April	Newly-emerged adult found in trunk.
Platygenia barbata, Afzel.	*Elaeis guineensis* ...	Leaves ...	Aug.	Adult.
Myoderma alutacea, Afzel.	,, ,,	Pollen ...	,, ...	,,
MELOLONTHIDAE.				
Pseudotrochalus concolor, Klb.	*Haematoxylon campechianum.*	Shoots ...	May, Aug. ...	Adults.
	Zea mais	Leaves ...	May	,,
	Gossypium hirsutum	,,	Aug., Sept. ...	,,
	Quisqualis indica ...	,, ...	Aug.	,,
	Spondias lutea ...	,, ...	Sept.	,,
	Citrus acida ...	,, ...	,, ...	,,
EROTYLIDAE.				
Megalodacne interrupta, Lac.	*Polyporus* sp. on dead trunk of *Pithecolobium saman*		April	Adults & larvae.
COCCINELLIDAE.				
Epilachna bomparti, Muls.	*Vernonia tenoreana*	Leaves ...	May, Oct. ...	Adults.
Epilachna similis, Thunb., var. *assimilis*, Muls.	*Zea mais*	,, ...	May	,,
	Unidentified grass ...	,, ...	Aug., Sept. ...	,,
	Gossypium spp. ...	,, ...	July, Aug., Sept.	Adults in cage containing cotton and Aphids, fed on plant, but did not attack Aphids.
	Urena lobata ...	,, ...	Aug.	
MELOIDAE.				
Cylindrothorax westermanni, Mäkl.	*Zea mais*	Pollen ? ...	May, June ...	Adults common on male flowers.
BUPRESTIDAE.				
Pseudagrilus sophorae, F.	*Gossypium* spp. ...	Leaves & stem.	Sept., Oct. ...	Adults feed on leaves, larvae bore into stem.
	Hibiscus esculentus	,, ...	July, Aug., Oct.	Adults on leaves in July and Aug., larvae in stem in Oct.
	H. sabdariffa ...	Leaves ...	July, Aug. ...	Adults.
	H. vitifolius ...	,, ...	June, Aug., Oct.	,,
	H. rostellatus ...	,, ...	July, Aug. ...	,,
	H. rosa-sinensis ...	,, ...	July	,,

COLEOPTERA—*Continued.*

Name.	Food-plants.	Part attacked.	Month of appearance.	Remarks.
BUPRESTIDAE—*Cont.*				
Pseudagrilus sophorae, F.	*Urena lobata* ...	Leaves ...	Aug.	Adults.
	Abutilon zanzibaricum	,, ...	June, Aug., Oct.	,,
	Sida carpinifolia ...	,, ...	June	,,
	Triumfetta rhomboidea.	,,	June, July, Oct.	,,
Agrilus capensis, Murr.	*Gossypium* sp. ...	,,	Aug.	,,
	Hibiscus rosa-sinensis	,, ...	July	,,
GALERUCIDAE.				
Ootheca mutabilis, Sahlb.	*Dolichos* sp. ...	Leaves ...	May, June, Aug.	,,
	Vigna sp.	,, ...	Sept.	,,
	Mucuna sp. ...	,, ...	April	,,
	Canavalia sp. ...	,, ...	May	,,
	Indigofera sp. ...	,, ...	,, ...	,,
Oïdes humeralis, Gah.	*Cissus arguta* ...	,, ...	June, Aug., Sept.	,,
Oïdes typographica, Rits., var.	*Triumfetta rhomboidea.*	,, ...	Aug.	Adults & larvae; pupal period 13 days.
HALTICIDAE.				
Nisotra uniforma, Jac.	*Gossypium hirsutum*	,, ...	Aug.	Only adults seen in each case.
	G. peruvianum ...	,, ...	July, Aug. ...	
	Hibiscus esculentus	Leaves & green fruit	Aug., Sept., Oct.	
	H. sabdariffa ...	Leaves ...	July, Aug., Sept.	
	H. rostellatus ...	,, ...	Aug.	
	H. rosa-sinensis ...	,, ...	Aug., Sept.	
	Urena lobata ...	,, ...	,, ,,	
	Abutilon zanzibaricum	,, ...	May, Aug., Oct.	
Nisotra ?dilecta, Dalm.	*Gossypium hirsutum*	Leaves ...	July, Aug. ...	Only adults seen in each case.
	G. peruvianum ...	,, ...	,, ,, ...	
	G. vitifolium ...	,, ...	Aug.	
	Hibiscus esculentus	Leaves & green fruit	Aug., Sept., Oct.	
	H. sabdariffa ...	,, ,,	July, Aug., Sept.	
	H. cannabinus ...	Leaves ...	Aug.	
	H. rostellatus ...	,, ...	,,	
	Urena lobata ...	,, ...	Aug., Sept.	
	Sida rhombifolia ...	,, ...	Aug.	
	Triumfetta rhomboidea	,, ...	,,	
Nisotra spadicea, Dalm.	*Gossypium vitifolium*	Leaves ...	Sept.	Only adults seen in each case.
	Hibiscus esculentus	,, ...	July	
	H. sabdariffa ...	,, ...	July, Aug. ...	
	H. rostellatus ...	,, ...	Oct.	
	H. rosa-sinensis ...	,, ...	Aug.	
	Urena lobata ...	,, ...	,,	
	Triumfetta rhomboidea	,, ...	,,	
	T. cordifolia var. *hollandii.*	, ...	Apr., July, Aug.	
	Mucuna urens ...	,, ...	Aug.	
CASSIDIDAE.				
Aspidomorpha dissentanea, Boh.	*Desmodium velutinum.*	Leaves ...	May	Only adults seen.
Aspidomorpha confinis, Klug.	*Urena lobata* ...	Leaves ...	Aug.	,, ,, ,,
CURCULIONIDAE.				
Lixus camerunus, Klb.	*Vernonia tenoreana*	Leaves ...	May to Aug. ...	Only adults seen, not feeding.
Apoderus fuscicornis, Oliv.	*Psidium guava* ...	Leaves ...	May	Adults.
	Quisqualis indica ...	.. ...	Aug.	,,

COLLECTIONS RECEIVED.

The following collections were received by the Imperial Bureau of Entomology, between 1st January and 31st March, 1927, and the thanks of the Managing Committee are tendered to the contributors for their kind assistance :—

Mr. E. Appenhagen :—373 Orthoptera ; from the Canary Islands.

Dr. G. Arnold, Rhodesia Museum :—18 Coleoptera ; from South Africa.

Mr. E. Ballard, Commonwealth Cotton Entomologist :—5 Diptera, 52 Coleoptera, 3 Hymenoptera and prey, 21 other Hymenoptera, 11 Lepidoptera, and 33 Rhynchota ; from Queensland, Australia.

Dr. F. S. Bodenheimer :—50 Diptera, 239 Coleoptera, 94 Hymenoptera, 47 Rhynchota, 335 Orthoptera, 6 Planipennia, 12 Odonata, and 4 Trichoptera ; from Palestine.

Mr. A. E. Brooks :—35 Coleoptera ; from New Zealand.

Mr. A. J. Brooks, Director of Agriculture :—1 Fly, 1 Mordellid beetle, 1 Chalcid, 1 Moth, 30 Rhynchota, and 1 Spider ; from the Gambia.

Dr. P. A. Buxton, London School of Hygiene and Tropical Medicine:—17 Coleoptera and 23 *Glossina* ; from England and the Gold Coast.

Chief Veterinary Research Officer, Nairobi :—8 Ticks ; from Kenya Colony.

Mr. E. C. Chubb, Durban Museum :—67 Diptera and 159 Rhynchota ; from South Africa.

Mr. G. H. Corbett, Government Entomologist :—264 Diptera, 298 Parasitic Hymenoptera, and 17 Rhynchota ; from the Federated Malay States.

Mr. D. D'Emmerez de Charmoy :—6 Coleoptera ; from Mauritius.

Director of Medical and Sanitary Services, Dar-es-Salaam :—4 Culicidae ; from Tanganyika Territory.

Division of Entomology, Pretoria :—36 Coleoptera and 4 Orthoptera ; from South Africa.

Dr. L. H. Dozier :—2 species of Aleurodidae ; from Venezuela.

Mr. P. R. Dupont :—3 species of Coccidae ; from the Seychelles.

Mr. V. M. Engelhardt :—60 Orthoptera ; from Eastern Siberia.

Mr. R. A. Farquharson :—30 Delphacid nymphs and a sample of *Sorghum vulgare* attacked by them ; from British Somaliland.

Mr. T. Bainbrigge Fletcher, Imperial Entomologist : -108 Parasitic Hymenoptera, 1 species of Aphidae, and 34 Orthoptera ; from India.

Dr. D. T. Fullaway :—29 Coleoptera ; from the Marianne Islands.

Mr. F. D. Golding, Government Entomologist :—6 Coleoptera and 7 Rhynchota ; from Southern Nigeria.

Mr. C. C. Gowdey, Government Entomologist :—19 Culicidae, 3 Psychodidae, 39 other Diptera, 2 Coleoptera, 11 Hymenoptera, 3 Lepidoptera, 1 species of Coccidae, and 3 Orthoptera ; from Jamaica.

Mr. W. Greenwood :—7 Diptera and 3 pupa-cases, 4 Coleoptera, 44 Parasitic Hymenoptera, 11 Lepidoptera, 15 species of Coccidae, and 52 Aphidae ; from the Fiji Islands.

Mr. G. L. R. Hancock, Assistant Entomologist :—36 Orthoptera ; from Uganda.

Mr. C. B. Hardenberg : 220 Coleoptera ; from Portuguese East Africa.

Mr. E. Hargreaves, Government Entomologist :—43 Diptera and 7 pupa cases, 230 Coleoptera and 50 early stages, 70 Parasitic Hymenoptera, 18 other Hymenoptera, 81 Lepidoptera and 3 cocoons, 20 Thysanoptera, 9 species of Coccidae, 1 species of Aphidae, 1 species of Aleurodidae, 31 other Rhynchota, 14 Orthoptera, 3 Planipennia, 2 Ephemeridae, and 2 Spiders ; from Sierra Leone.

Mr. H. Hargreaves, Government Entomologist :—23 Culicidae, 8 Coleoptera, 6 Parasitic Hymenoptera, 10 Lepidoptera, 404 Rhynchota, 56 Odonata, and 2 Planipennia ; from Uganda.

Dr. Walther Horn :—248 Orthoptera ; from China, Transcaspia, and the Persian Gulf.

Mr. G. F. Hucklesby :—42 Diptera, 100 Coleoptera, 82 Hymenoptera, and 12 Rhynchota ; from Palestine.

Mr. M. Afzal Husain, Government Entomologist :—3 Parasitic Hymenoptera and 1 species of Aleurodidae ; from the Punjab, India.

Mr. J. C. Hutson, Government Entomologist :—14 species of Aphidae ; from Ceylon.

Imperial Institute, London :—1 Pyralid moth and 3 cocoons from cocoa beans ; from Jamaica.

Inspector-General of Agriculture, Baghdad :—1 species of Coccidae ; from Iraq.

Mr. R. W. Jack, Chief Entomologist :—12 Diptera, 2 Coleoptera, 3 Parasitic Hymenoptera, and 3 Lepidoptera ; from Southern Rhodesia.

Mr. L. G. E. Kalshoven :—239 Lepidoptera ; from Java.

Mr. S. Keler :—10 Hymenoptera ; from Poland.

Mr. C. R. Kellogg :—204 Coleoptera and 20 Rhynchota ; from China.

Prof. F. J. Meggitt :—1 Reduviid bug and 48 Orthoptera ; from Burma.

Mr. D. Miller, Government Entomologist :—1 Braconid ; from New Zealand.

Mr. C. S. Misra :—49 Parasitic Hymenoptera ; from Bengal, India.

Museum d'Histoire Naturelle, Paris :—97 Orthoptera ; from Russia and the Canary Islands.

Niger Company, Ltd., London :—21 Rhynchota ; from Nigeria.

Mr. L. Ogilvie, Plant Pathologist :—1 Pyralid moth and 39 Rhynchota ; from Bermuda.

Mr. R. W. Paine :—200 Mites ; from the Fiji Islands.

Mr. C. Papachrysostomou :—67 Coleoptera, 31 Parasitic Hymenoptera, 5 Lepidoptera, and 8 Rhynchota ; from Cyprus.

Mr. H. M. Pendlebury :—389 Coleoptera ; from the Federated Malay States.

Mr. A. W. J. Pomeroy, Government Entomologist :—675 Isoptera ; from the Gold Coast.

Mr. A. H. Ritchie, Government Entomologist :—18 Culicidae, 53 other Diptera, 124 Coleoptera, 4 Hymenoptera, 3 Lepidoptera, 35 species of Coccidae, and 23 other Rhynchota ; from Tanganyika Territory.

Mr. H. W. Simmonds, Government Entomologist :—15 Coleoptera, 3 Hymenoptera, 34 Lepidoptera, 6 Rhynchota, and 2 Orthoptera ; from the Fiji Islands.

Mr. C. B. Symes, Medical Entomologist :—277 Siphonaptera and 890 Culicidae ; from Kenya Colony.

Mr. F. H. Taylor :—13 Coleoptera ; from North Queensland, Australia.

Mr. O. Theodor :—264 Diptera, 313 Coleoptera, 58 Hymenoptera, 31 Rhynchota, 2 Psocidae, and 2 Embiidae ; from Palestine.

Mr. H. P. Thomasset :—8 Culicidae, 67 other Diptera, 156 Coleoptera, 54 Hymenoptera, 440 Lepidoptera, 111 Rhynchota, 3 Orthoptera, 3 Planipennia, 5 Odonata, 2 Trichoptera, and a number of Mites ; from Natal.

Dr. W. R. Thompson :—11 Parasitic Hymenoptera ; from France.

Mr. D. Tratnikov :—1 Curculionid and 4 Orthoptera ; from Central Asia.

Mr. R. Veitch, Chief Entomologist :—142 Rhynchota ; from Queensland, Australia.

Wellcome Tropical Research Laboratories, Khartoum :—1,180 Coleoptera, 2 Lepidopterous larvae, 621 Rhynchota, 6 Orthoptera, and 550 Mallophaga ; from the Sudan.

Mr. H. Wilkinson :—1 species of Aphidae and 34 Anoplura ; from Kenya Colony.

Mr. B. Zolotarewsky :—28 Orthoptera ; from Madagascar.

STUDIES IN AFRICAN TACHINIDAE (DIPTERA).—II.

By C. H. Curran.

In several previously published papers dealing with African Diptera I have described a number of species belonging to the genus *Sturmia*, Desvoidy, but up to the present time have not had sufficient material available to warrant the preparation of a key to the species, nor have I had an opportunity of studying the species in sufficient detail to decide upon characters of value in their classification. However, since many species were reared and it was desirable to have names for them in order that they might be used in reports by various Entomologists in Africa, a number of the species were described, and it has since been possible to make considerable progress in the study of the whole. As a result a key to the species belonging to this genus is now presented, and it is hoped that it will be of assistance in identifying the representatives of this difficult group.

It is further hoped that arrangements may be made in the near future for the publication of a key to the genera of the Tachinidae, since it is obvious that with the very large number of genera described, the description of an additional genus, or even of new species in old genera, conveys little of the true relationships of the forms described and merely adds to the difficulty of making determinations.

Tachinidae.

Dexia, Meigen.

In Africa there are many species belonging to the genus *Dexia*. For the most part these rather closely resemble *Dexia rustica*, Fabricius, in general appearance, but there are two species in which the male is of a more slender and elongate form, although this character does not hold good in the opposite sex. The characters enumerated below will serve to distinguish the genus from its close allies.

In all the males there are discals on at least the fourth abdominal segment, and very frequently on the intermediate ones, but the females wholly lack discals. The prosternum and propleura are bare and the infra-squamal setulae absent ; presutural acrostichals poorly developed, sometimes absent, usually represented by one, rarely by two pairs, while there may be either one or two pairs of post-sutural acrostichals. The dorsocentrals vary from two to three pairs in front of the suture, while there are always three post-sutural pairs. Three pairs of strong marginal scutellars, the apical pair cruciate, and usually a pair of weak discals. Sternopleurals 1–1. The bend of the fourth vein usually bears a short, strong appendage, but this may sometimes be absent, while the costal spine is long and strong. The facial carina may be wholly sharp and of almost uniform width or narrow on the upper portion with the lower portion broadened and flattened. The antennae extend a little more or a little less than half-way to the vibrissae, which are situated far above the oral opening, the clypeal region lengthened and narrowed ; third antennal segment from one and one-half to twice as long as the second.

I have not seen examples of any of the previously described species from Africa, but I doubt if those described by Walker and Wiedemann from South Africa belong to the genus. I present a key for the separation of the African species and include *rustica* in order to show its relationship to the others.

Table of Species.

1.	Legs reddish	2
	Legs black	8
2.	Bend of fourth vein with appendage	3
	Bend of fourth vein without appendage	7

(K 3401) Wt P3/D46 1,000 11/27 Gp 52

3. Third vein with two or three basal setae, if with two the abdomen not vittate 4
Third vein with a single basal seta; abdomen vittate ... *uniseta*, sp. n.
4. Facial carina broadened and rather flattened below; antennae reaching less than half way to vibrissae 6
Facial carina sharp throughout; antennae reaching at least half way to vibrissae 5
5. Pollen brown-ochreous; veins strongly clouded with brown (Cape) *afra*, sp. n.
Pollen cinereous; veins weakly clouded with brownish (Europe) *rustica*, Fabr.
6. Abdomen with median dark vitta (Kenya) ... ... *orphne*, sp. n.
Abdomen with black apical segmental fasciae (Cameroons) *venusta*, sp. n.
7. A broad median vitta and lateral margins of the abdomen blackish, the intervening yellowish area whitish pollinose ... ... *varivittata*, sp. n.
Abdomen with median dark vitta and yellowish pollen (Uganda) *inappendiculata*, Aust.
8. Mesonotum with four black vittae (Cape) ... ... *pusio*, Walk.
Mesonotum with three black vittae (Cape) ... ... *lugens*, Wied.

Dexia afra, sp. n.

Appearing brownish ochreous; thorax in part, a median abdominal vitta and part of the occiput, black in ground-colour, the integument elsewhere reddish yellow; tarsi brown. Length, 8 to 11 mm.

♂. *Head* greyish-white pollinose, the occiput above and the parafrontals, ochreous; cheeks with a reddish band in front. Front half as wide as either eye, strongly widening anteriorly. Frontal vitta black or brown; seven or eight pairs of frontals; occipital cilia connected with the sparse black hair of the cheeks, the sparse pile yellowish. Cheeks half as wide as eye-height. Palpi short, stout, reddish. Vibrissae situated half-way between oral margin and end of carina, the latter wholly sharp. Antennae reaching half-way, or slightly more, to the vibrissae, the rays of the arista black. *Thorax*: mesonotum black, with the broad sides, scutellum, pleura in front and behind and along the sutures, pale, the extent of the dark colour evidently variable. Pleura with greyish tinge below, the mesonotum with brownish tinge, the four vittae quite weak; hair wholly black. Acrostichals 1 or 2–1; dorsocentrals, 3–3; scutellum with a pair of weak discals. *Wings* greyish hyaline, with brownish clouds along the veins and brown tinge anteriorly on the basal half, the anterior cross-vein strongly clouded. Lower squamal lobe with luteous tinge; halteres reddish. *Abdomen* with the colour largely concealed by the pollen: the black vitta is moderately narrow, widens slightly on the apices of the intermediate segments and tapers to the tip of the fourth segment. First segment without marginals, the second with a pair, the third and fourth each with a row; third segment with a pair of discals, the fourth with a row. Hair sparse, coarse, black.

♀. Front about one-fourth wider than either eye; two pairs of strong orbitals; outer verticals absent; pleura almost all pale, the mesonotum more ferruginous in ground-colour; no discal scutellars; abdomen without discals, with the black vitta obsolete on the fourth segment, the disc of the basal segments broadly brownish pollinose.

Type ♂, Durban, Natal, 24.iii.1914 (*W. J. Hogarth*), in the British Museum. Allotype ♀ and ♀ paratype, Karkloof, Natal, 15.i.1917 (*A. J. T. Janse*); the allotype in the Munro collection.

There is a third female from Yaba, S. Nigeria, 22.ii.1911 (*Dr. W. M. Graham*), which is very similar, but I think it belongs to a different species, since it has the wings of a more brownish colour, stronger bristly hairs on the costa, paler antennae, etc. Until more material is available from this region the specimen is doubtfully placed here.

Dexia uniseta, sp. n.

Length, 11 mm. In general colouration this species is similar to *afra*, the obvious differences being as follows: ♀. Front black, greyish-brown pollinose above; occiput mostly black; antennae reaching decidedly less than half-way to the vibrissae; arista black. Thorax coloured as in ♂ of *afra*; no presutural acrostichals; a pair of scutellar discals. Wings with the veins so broadly clouded with greyish brown as to leave only the middle of the cells clear; squamae white. Abdominal vitta as in ♂ *afra*, the tips of the intermediate segments dark; bristles as in ♀ *afra*. The third vein bears but a single small basal seta.

Type ♀, Weenen, Natal, x–xi. 1924 (*H. P. Thomasset*); in the British Museum.

Dexia orphne, sp. n.

Length, 11 mm. ♂. Having the general colouration of *afra*, even to the wings, but decidedly paler, since there is much less brownish tinge, the underside of the abdomen is without pollen, there is no brown pollinose abdominal vitta and the black vitta extends only to the apex of the third segment.

Antennae short, reaching much less than half-way to the vibrissae; frontal pollen with ochreous tinge above; frontal vitta brownish red, the front two-fifths as wide as either eye. Facial carina very narrow above, strongly broadened and flattened below. Mesonotal vittae fairly distinct; acrostichals 1–2; a pair of discal scutellars. Legs mostly missing. Abdominal pollen cinereous yellowish, darker along the median vitta. Second and third abdominal segments each with a pair of discals, the second with a pair, third and fourth each with a row of marginals, the fourth with a row of discals.

Type ♂, Southern Masai Reserve, Kenya Colony, 28.iv.1913 (*T. J. Anderson*); in the British Museum.

Dexia venusta, sp. n.

Rusty yellowish, the mesonotum brownish; abdomen with irregular black fasciae. Length, 8 to 10 mm.

♂. *Head*: front three-tenths as wide as either eye, gently widening anteriorly; seven or eight pairs of frontals; vitta rusty reddish; occiput with sparse yellowish hair below the neck, mostly black in ground-colour. Cheeks half as wide as eye-height, rusty reddish anteriorly. Head whitish pollinose. Palpi yellow. Antennae reddish yellow, reaching half way to the vibrissae. Facial carina broadened on lower half. *Thorax*: mesonotum rusty brownish except the very broad sides, yellowish pollinose, the vittae brownish; pleura whitish pollinose. Acrostichals, 1–2; dorsocentrals, 2–3; discal scutellars weak or absent. Hair wholly black. *Legs* moderately long, the tips of the femora black; tarsi black. *Wings* and squamae luteous; third vein with three basal setae. Halteres reddish yellow. *Abdomen* with first and second segments narrowly, irregularly brownish or blackish apically, the third and fourth each with a fairly broad, medianly interrupted, laterally narrowing, opaque black fascia. Abdominal pollen yellowish, not conspicuous, very narrowly whitish on the base of the second and third segments. Second and third segments each with a pair of discals, the fourth with a row; second segment with pair, the third and fourth each with row of marginals.

♀. Front about as wide as either eye, brownish golden pollinose; mesonotal pollen brownish except laterally; wings with more brownish tinge on apical half in front; second abdominal segment with more or less distinct, large median brown triangle resting on the apex and fairly wide apical fascia; third segment sometimes with a still larger ferruginous triangle, the fourth as in the male or ferruginous except basally. No discals.

Type ♂, allotype ♀, N. Cameroons (*Conradt*). Paratypes: ♂, same data; ♂♀, Cameroons (*Conradt*). An additional ♂ lacks abdomen. Types in Deutsch. Ent. Institut, Dahlem, Berlin.

Dexia varivittata, sp. n.

A rather elongate, slender species, closely related to *inappendiculata*, Austen, but differently coloured, the ♀ of the usual form. Length, 11 to 14·5 mm.

♂. *Head* dark rusty reddish, silvery grey pollinose, the parafacials with yellowish tinge; occiput mostly and the upper third of the front blackish in ground-colour; frontal vitta brownish red. Front two-fifths as wide as either eye; seven or eight pairs of frontals; ocellars long and strong. Pile of the occiput pale yellowish; hair of cheeks fine and black. Palpi reddish. Vibrissae situated almost on a level with the lower end of the carina, which is broad below. Antennae reaching more than half way to the vibrissae, brownish red; aristal rays black. *Thorax* greyish pollinose, usually with slight yellowish tinge; mesonotal vittae black, narrow, distinct, between each pair the ground-colour obscured by brown pollen, which spreads to cover the whole disc behind the suture and forms two broad brown vittae in front of the suture, the mesopleura less deeply brown on the upper half. Acrostichals, 0–1; dorsocentrals, 3–3; scutellar discals weak. *Legs* very long, reddish; tarsi black. *Wings* light brownish; third vein with two or three basal setae; no appendage at bend of fourth vein. Squamae luteous; halteres yellowish. *Abdomen* with very broad median and lateral vittae and a narrow medio-ventral vitta, blackish or brown, leaving four broad, pale vittae, two above which unite on the fourth segment but extend only slightly on the base and two below which extend to the apex of the abdomen along the lower edges of the apical tergite. The dorsal pale vittae are whitish pollinose, with a yellowish tinge on the basal half, and they cover most of the fourth segment; median blackish vitta brown pollinose, the venter almost without pollen except towards the middle; fourth segment more or less broadly reddish yellow apically; genitalia reddish. First segment without bristles; second with pair of discals and marginals: third and fourth each with row of discals and marginals and sometimes with an additional pair of discals anteriorly.

♀. *Head*: front and parafacials rich deep brown pollinose, the front pollen opaque black tessellate in some views, the posterior orbits with brown tinge; head blackish in ground-colour. Front a little wider than either eye, with two pairs of orbitals; outer verticals slightly developed. Thorax brownish pollinose, the lateral margins, scutellum and part of the pleura, paler; scutellum without discals. Abdomen black or dark brown, with broad grey pollinose vittae in place of the white ones, the venter with rather thin grey pollen except on the very broad sides. There are no discal bristles.

Type ♂, allotype ♀, and 6♂ paratypes, Buea, S. Nigeria. The types are in the Deutsch. Ent. Inst., Dahlem, while a paratype is deposited in the British Museum through the courtesy of Dr. Walther Horn.

Pretoriamyia, gen. nov.

Infrasquamal setulae absent; propleura and prosternum bare; apical cell ending very close to wing-tip. Face, in profile, scarcely concave, with a distinct, short carina above, the oral margin produced, the head below five-sixths as long as high; arista plumose; antennae reaching two-thirds the distance to the oral margin, third segment twice as long as second, obtusely rounded apically. Front of ♂ one-fourth, of ♀ one-third as wide as either eye; six or seven pairs of rather weak frontals, none below the base of the antennae, none reclinate; ♀ with two pairs of poorly differentiated orbitals; ocellars strong. Cheeks one-fourth as wide as eye-height. Apical section of proboscis one-sixth longer than head-height; palpi long

and slender, somewhat widened apically. Eyes bare. Acrostichals 2–2, rarely 3–2, the second presutural pair strongest ; dorsocentrals, 2–3 ; posterior sub-lateral and posthumeral bristles absent ; 2 intra-alars, 1 supra-alar and a weak pre-alar ; sternopleurals 2–1, the lowest quite weak ; 3 pairs of marginal scutellars, the apical pair cruciate, usually a pair of weak discals, the scutellum otherwise bare. Legs a little elongate, slender, with very fine, short bristles. Wings rather narrow ; apical cell open or closed in the costa ; posterior cross-vein gently oblique, joining the penultimate section of the fourth vein at its middle ; third vein with a single weak basal seta. Squamae large, broad. Abdomen elongate, gently tapering ; no discals ; first and second segments each with a pair of marginals, the third and fourth each with a row, the fourth with a sub-marginal row of bristles ; a pair of hairs on the third segment sometimes simulating discals. Legs of ♀ shorter than in ♂.

Genotype : *P. munroi*, sp. n.

The head characters of this genus are truly Dexiine, and the superficial resemblance to *Arrhinomyia* is striking, although the colour is remarkably like that of *Succingulum*.

Pretoriamyia munroi, sp. n.

Black, the second and third abdominal segments of the ♂ with broad, reddish yellow basal fasciae. Length, 4 to 4·5 mm.

♂. *Head* greyish pollinose, the frontal vitta brown ; face yellowish. Occiput pale-haired below the neck ; hair black ; parafacials and parafrontals bare. Palpi brown. Antennae blackish ; third antennal segment pubescent ; aristal rays half as long as width of third antennal segment. *Thorax* densely greyish pollinose, with an opaque black band occupying the anterior two-thirds of the post-sutural area. Hair black. Scutellum black, with the apical third grey. *Legs* black ; pulvilli elongate. *Wings* cinereous hyaline. Squamae with brownish tinge. Halteres yellow. *Abdomen* opaque brown and black, the venter yellowish to beyond the middle of the third segment ; second segment with a broadly interrupted yellowish fascia occupying the basal half to two-thirds, the third segment with a similar fascia on the basal half, the basal half of these segments thickly whitish pollinose, the fourth segment with the pollen occupying the basal three-fourths, more greyish. Hair black.

♀. There is very little pale ground-colour on the abdomen, but the pollen is somewhat denser and has a yellowish tinge.

Type ♂, Pretoria, S. Africa, 12.i.1918 ; allotype ♀, Pretoria, 4.xii.1918. Paratypes : 2♂♂ 1♀, Pretoria, 22.ii.1913, 12.i.1918 and 28.xii.1913 (all *H. K. Munro*). Type in Munro Collection ; paratype in British Museum.

Afromeigenia, gen. nov.

Superficially very similar to *Ochromeigenia*, Townsend, but without infra-squamal setulae and with tiny setulae in two rows on the parafacials. In this latter respect it approaches *Cryptomeigenia*, Br. & Berg. (which also has infra-squmal setulae), but the oral margin is very strongly carried upwards on its anterior third, shortening the face much more than in that genus and the ocellar bristles are scarcely evident.

Face strongly retreating to the lower third, thence slightly produced to the vibrissal angles ; parafacials twice as wide as antenna, wider than the front in the ♂ ; front wide in the ♀, with two pairs of orbitals. True occiput with converging rows of black setulae. Palpi long. Antennae narrow, long, reaching the lower fifth of the face, rising slightly below the middle of the eyes ; eight to ten pairs of quite weak, short frontals, none situated below the base of the antennae and none reclinate ;

chitinized occiput not carried far forward on the cheeks, which are mostly soft and one-third as wide as eye-height. Proboscis short, the labella large. Acrostichals 1–1 or 0–1; dorsocentrals, 2–3; posterior sub-lateral and post-humeral bristles absent; 2 intra-alars; 1 supra-alar; sternopleurals 2–1 or 1–1; 2 pairs of marginal scutellars, the apical pair cruciate; propleura bare; prosternum with a pair of black bristles; infra-squamal setulae absent. Legs not elongate; anterior tibiae with dorsal and posterior bristle at apical third; middle tibiae with a median postero-dorsal, one beyond the apical third, and antero-dorsal and ventral bristle beyond the apical third; posterior tibiae with two antero- and postero-dorsal and one antero-ventral bristles; claws and pulvilli elongate. Wings rather narrow; apical cell open, ending slightly before the wing-tip, the bend of the fourth vein rather sharply rounded; posterior cross-vein ending before the middle of the penultimate section of the fourth vein; fourth vein setulose more than half-way to the anterior cross-vein. Abdomen oval, without discals; second segment with a pair of marginals, the third and fourth each with a row.

Genotype: *A. pallens*, sp. n.

Afromeigenia pallens, sp. n.

Rusty yellowish; claws black. Length, 4·5 to 6 mm.

♂. *Head* thickly white pollinose; frontal vitta orange; ocellars scarcely distinct; occipital cilia fine, short, extending along the inner edge of the occiput and over the posterior portion of the cheeks; palpi with black bristles; vibrissae situated level with the oral margin; third antennal segment twice as long as second, with parallel sides, the apex obtusely rounded; arista thickened on basal fourth, weakly pubescent. Front one-fourth as wide as either eye. *Thorax*: mesonotum with yellowish, the pleura with whitish pollen; no vittae; hair wholly black. *Wings* cinereous hyaline; veins luteous. Squamae and halteres yellowish. *Abdomen* thinly yellowish pollinose dorsally; somewhat more rusty apically. Hair wholly black.

♀. Front half as wide as either eye, with two pairs of very weak orbitals situated just outside the frontal row; outer verticals long. In front of the segmental apices there are slight indications of dark fasciae.

Type ♂, East London, South Africa, 9.xi.1921 (*H. K. Munro*); allotype ♀, Bloemfontein, S. Afr., 2.ii.1921 (*H. E. Irving*). Paratypes: ♀, Pretoria, 9.ix.1914 (*A. J. T. Janse*); ♀ Esho, Natal, 1.i.1916 (*A. J. T. Janse*); ♂, New Hanover, Natal, 17.xii.1914 (*C. B. Hardenberg*); ♀, Njala, Sierra Leone, 17.iv.1925, at light (*E. Hargreaves*). Types in Munro Collection; paratype in the British Museum.

Viviania flava, sp. n.

Yellowish, the mesonotum rust-reddish; third antennal segment and tarsi black. Length, 6 to 7 mm.

♂. *Head*: front almost one-third as wide as either eye, strongly widening anteriorly. Parafrontals and occiput yellowish pollinose, the face, posterior orbits and the front below, with cinereous or whitish pollen; eight or nine pairs of weak frontals, the upper pair reclinate; no frontal hair; ocellars very weak; a single row of black occipital cilia which extend across the cheeks; pile sparse, yellowish. Cheeks one-third as wide as eye-height. Facial ridges bristled on almost the lower fourth. Third antennal segment almost three times as long as the second; arista black on basal two-thirds, thickened on basal fourth, sparsely short pubescent. Parafacials usually with a row of obscure hairs on the upper half. *Thorax* with cinereous white pollen, that on the dorsum with yellowish tinge, the vittae obscurel Acrostichals, 1–2; dorsocentrals, 2–3; posterior sub-lateral and post-humera. bristles absent; 2 intra-alars; one supra-alar and a weak pre-alar; sternopleurals 1–1; 3 pairs of marginal scutellars, the apical pair not cruciate. Prosternum bare or

with two weak hairs ; propleura bare ; infra-squamal setulae present. Hair wholly black. *Legs* with black hair ; pulvilli elongate. *Wings* cinereous hyaline, with yellowish tinge towards the base in front ; posterior cross-vein beyond the middle of the penultimate section of fourth vein ; apical cell ending a little before the wing-tip ; third vein with a single basal seta. Squamae yellowish. *Abdomen* very thinly whitish pollinose, the bases of the segments more conspicuously so. First and second segments each with a pair of marginals, the third and fourth each with a row ; second to fourth segments each with pair of discals.

♀. Front two-thirds as wide as either eye ; frontal vitta rusty reddish ; two pairs of weak orbitals.

Type ♂, Njala, Sierra Leone, 28.iii.1925, at light ; allotype ♀ and ♀ paratype, Njala, 21.v.1926 ; ♀, Njala, 16.v.1926, at light ; ♀, Mayamba, Sierra Leone, 6.viii.1925 (all *E. Hargreaves*). Types in the British Museum.

Sturmia, Desvoidy.

Sturmia, Desvoidy, Myodaires, p. 171, 1830.

Blepharipa, Rondani, Dipt. Ital. Prod., i, p. 71, 1856.

Cienocnemus, Kowarz, Verh. zool.-bot. Ges. Wien, xxii, p. 460, 1873.

Crossocosmia, Mik, Wien. Ent. Zeitg., lx, p. 313, 1890.

Xylotachina, Brauer & Bergenstamm, Denks. Akad. Wien, lviii, p. 342, 1891.

Siphosturmia, Coquillett, Revis. Tachinidae, p. 83, 1897.

Polychnomyia, Bischoff, Verh. zool.-bot. Ges. Wien., liv, p. 85, 1904.

Congochrysosoma, Townsend, Ann. Mag. Nat. Hist., xvii, p. 174, 1916.

This genus comprises a very large number of species occurring in all parts of the world and is represented in Africa by more than fifty species. The exact limits of the genus are rather difficult to define because of a certain amount of variation in any characters which may be selected as being of generic value. In some species the parafacials are wholly bare, while in others they bear short hair on their whole length, but there are numerous intergrading forms. In all the species but one which have been examined the prosternum bears either hair or bristles laterally, the propleura is bare and there are no infra-squamal setulae. The face is moderately retreating or only slightly so, the facial ridges never bristled quite to the middle, usually on less than the lower third, the bristles becoming weak and hair-like upwardly. The vibrissae are situated slightly to moderately above the oral margin. Palpi broadened on apical half to third. Front of ♂ one-half to fully as wide as either eye (usually wider in ♀ of same species), with from eight to ten pairs of frontals, which become weak towards the upper third, the upper one to three pairs, however, much strengthened and reclinate. Cheeks varying from one-tenth to one-third as wide as eye-height. Ocellar bristles varying from absent to very strong, sometimes weak in ♂ and very strong in ♀ of same species. Thorax with the bristling complete : acrostichals, 3–3 ; dorsocentrals, 3–4 ; sternopleurals variable ; 5 pairs of marginal scutellars, the apical pair weaker and cruciate, and a pair of weak discals. Posterior tibiae closely ciliate or with only moderately closely spaced cilia ; pulvilli elongate or short in the ♂. Wings with normal venation, the third vein ending far before the wing-tip ; apical cell open ; bend of fourth vein sharp, without appendage ; the posterior cross-vein joins the penultimate section of the fourth vein near its apical third. Squamae large, broadened. Abdomen broader than deep, without discals on the basal three segments, with or without marginals on the basal two. Genital opening closing slit-like or not. Males usually with ventral sexual patch on third segment. The type of the genus is *S. vanessae,* Desvoidy.

In the Palaearctic Catalogue *S. vanessae* is included in the subgenus *Argyrophylax* Br. & Berg., which is quite erroneous, since this latter genus is very distinct from *Sturmia*. As used in the catalogue, however, *Argyrophylax* represents the typical forms belonging to the genus *Sturmia*.

Siphosturmia, Coquillett, is based upon species of *Sturmia* in which the face is but slightly retreating and the proboscis slightly longer than in typical forms, but such species are quite numerous in Africa and the Orient, and it is altogether impossible to draw any line of distinction between these and the typical forms.

Polychnomyia, Bischoff, is nothing more than a representative of the subgenus *Crossocosmia*, Mik. This latter group can hardly be considered as forming a subgenus, owing to the impossibility of placing many of the forms in either group.

Congochrysosoma, Townsend, is similar to *Siphosturmia*, Coq., the only difference I could find in the types being that the parafacials are haired or setose on the upper half in the former, and wholly bare below the frontals in the latter. This character is of little importance from the generic standpoint, since it is most variable, and there are some species which it is difficult to place in either group, as it is sometimes difficult to decide whether the setae are normal or adventitious.

The variability of characters renders the use of any key somewhat difficult, but I have attempted to use characters which are readily discernible. The fact that most of the characters used for the separation were not mentioned by the older writers makes the identification of their species practically impossible. In view of this condition it appears most likely that I have redescribed all the unrecognized species listed, and if such is the case, it is to be hoped that the correct synonymy may be quickly pointed out. Dr. J. Villeneuve has been kind enough to look over all the material I have had from the Belgian Congo and has identified several of the older species. Without his assistance it would have been impossible to identify any of the previously described forms.

The key has been prepared in two parts, one for each sex. It will be noticed that females of several species, probably all undescribed, are included in the key to this sex. It seems quite inadvisable to describe representatives of this sex without the male, unless the characters are unusually distinctive. In many cases, too, I have included representatives of one sex or the other in the respective tables, on the presumption that they will be found to bear the characters ascribed to them, but only when such characters are quite striking in the sex already known. In some cases the unknown sex of a species may trace out readily in the key to the opposite sex; this is particularly true of males, most of which will trace out fairly well in the female key.

A large number of the specimens studied have been reared, and as a result their condition is often as to render accurate determination almost impossible, since owing to injury, certain characters have not developed normally. In such circumstances it is often somewhat difficult to decide into which category a species falls, and one may be easily misled. From the economic standpoint the genus is a very important one in Africa, and most of the species attack major pests of staple crops.

Key to Males of Sturmia.

1. Sternopleurals 2–1–1, the third nearer the fourth than the first ... 2
   Two or three sternopleurals, or if with four, the third situated nearer the first than the fourth... 21
2. With sexual patch on the lower surface of the third tergite, rarely weakly developed, in which case the ocellars are long 3
   Without sexual patch ... ... *negator*, Curran

3. Parafacials bare on lower third or more 4
Parafacials with hair on whole length ... ... **femineum*, Curran.

4. Middle tibiae with only one antero-dorsal bristle 7
Middle tibiae with two antero-dorsal bristles 5

5. Parafacials bare below the lowest frontals 6
Parafacials setose half way below the lowest frontals ... ... *rex*, Curran.

6. Arista thickened to beyond the middle; sexual patch not visible from above ... ... *atropivora*, Desv.
Arista thickened on basal third; sexual patch extending far on to the dorsum ... ... *completa*, sp. n

7. A row, or at least half a row, of setulae behind the occipital cilia ... 8
At most a few isolated setulae behind the cilia on the upper half of the occiput 18

8. Sexual patch roundish, oval or cordate, or the occiput without a complete row of setulae behind the cilia 11
Sexual patch transverse, sub-rectangular: occiput with a complete row of setulae behind the cilia 9

9. Parafacials somewhat narrowed below, on most of their length narrower than the third antennal segment 10
Parafacials not narrowed below, wider than the third antennal segment *ugandana*, Curran.

10. Ocellars and marginals on second abdominal segment long and strong *potina*, sp. n.
Ocellars and marginals on second abdominal segment short *lavinia*, Curran.

11. Row of occipital setulae entire or nearly so 12
Row of setulae interrupted near the middle for at least one-third the length of the eye 16

12. Pollen never golden yellow on abdomen 13
Pollen of whole insect golden yellow; palpi black; no small marginals on second abdominal segment ... ... *pulchra*, Curran

13. Parafacials normally with yellow tinge; front scarcely more than half as wide as either eye 14
Parafacials pure white; front three-fourths as wide as either eye *inconspicua*, Meig.

14. Segmental pollen poorly limited behind, the apical half of the segments appearing black from most views 15
Abdominal pollen sharply limited, less than the apical fourth of the segments black; sexual patch large, cordate; bristles on first and second abdominal segments usually inconspicuous ... *cordata*, Curran.

15. Palpi brown on basal half or more; length, 12 mm. ... *gilvoides*, sp. n.
Palpi brown only at the base; length under 9 mm. ... *gilva*, Hartig.

16. Parafacials narrowed below, in part narrower than the third antennal segment 17
Parafacials not narrowed below, as wide as or wider than the third antennal segment; palpi black with the apical bare area reddish *dilabida*, Villen.

17. Palpi wholly deep black; ocellars long and strong ... ... *munroi*, Curran.
Palpi mostly pale reddish; ocellars short and weak ... *bimaculata*, Hartig.

18. Front three-fourths as wide as either eye (in ♀ as wide as eye) 19
Front about half as wide as eye (in ♀ three-fourths as wide as eye); abdominal pollen at most with slight yellowish tinge; apical half of second abdominal segment shining medianly... ... *zonata*, Curran

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*Described from opposite sex and presumed to trace here.

19. Mesonotum with ashy white pollen and shining black vittae 20
Mesonotum with yellowish cinereous pollen and narrow, dull vittae *laxa*, Curran.
20. Palpi reddish; third antennal segment over twice as long as second *partitor*, sp. n.
Palpi black; third antennal segment about one and one-half times as long as second ... ... *masakensis*, sp. n.
21. With three or more sternopleurals 23
With only two sternopleurals 22
22. Legs reddish ... ... *anaphe*, sp. n.
Legs black ... ... *instabilis*, sp. n.
23. Sternopleurals 2–1 or more than three 24
Sternopleurals 1–2 ... ... *aureiventris*, Villen.
24. Femora black 27
Femora reddish 25
25. Wings hyaline, sometimes yellowish basally 26
Wings yellowish basally in front, brownish at least along the veins *laetabilis*, Villen.
26. Parafacials almost twice as wide as third antennal segment *rufina*, sp. n.
Parafacials about as wide as third antennal segment ... *anaphe*, Curran.
27. Second abdominal segment with long, strong marginals 28
Second abdominal segment with at most very short marginals 35
28. Pollen cinereous or greyish yellow; face whitish 29
Pollen dark cinnamon-brown; face deep golden yellow ... *vivax*, Curran.
29. Ocellars long and strong 30
Ocellars short and weak; sternopleurals 2–1 32
30. Sternopleurals 2–1; front almost as wide as either eye 31
Sternopleurals 1–1–1, in an almost straight line; front little more than half as wide as either eye ... ... *angustifrons*, Villen.
31. Parafacials setose on upper half ... ... *instabilis*, sp. n.
Parafacials bare ... ... *semitestacea*, Villen.
32. Sexual patch restricted to the lower surface 33
Sexual patch extending distinctly on to the dorsum (Kenya) *scutellata*, Desv.
33. Parafacials setose above 34
Parafacials bare ... ... *alacris*, sp. n.
34. Wings broadly brownish in front on basal half ... ... *rex*, Curran.
Wings hyaline ... ... *analis*, sp. n.
35. Males without sexual patch; pulvilli small 36
With sexual patch of dense short hair on ventral part of third tergite ... 37
36. Third antennal segment about five times as long as the second (*doris*, Curran, not Schiner)... ... ... *dorina*, n. n.
Third antennal segment about two and one-half times as long as the second ... ... *chapini*, Curran.
37. Pulvilli large 40
Pulvilli small 38
38. Ocellars short and weak; parafacials setose above 39
Ocellars long and strong; parafacials bare ... ... *angustifrons*, Villen.
39. Parafacials almost one and one-half times as wide as third antennal segment, prominent in profile ... ... *vulnerata*, Curran.
Parafacials scarcely wider than third antennal segment, not prominent in profile ... ... *imitator*, Curran.
40. Abdomen rarely metallic green beneath the pollen, but if partly so, the pollen paler and the apex of the abdomen more or less reddish ... 41
Abdomen very strongly metallic green beneath the cinnamon-brown pollen, the apex black; unless moistened the abdomen may show only slight metallic green reflections in dried specimens ... *versatilis*, Villen.

41. Mesonotum greyish or greyish yellow pollinose, the sides cinereous or with greyish yellow pollen 44
Mesonotum cinnamon-brown or ochreous brown pollinose, the sides never greyish 42
42. Face golden yellow pollinose ; abdominal pollen white 43
Face white pollinose ; abdominal pollen rather ochreous ... *arrogans*, Curran.
43. Pollinose band on third abdominal segment narrow, interrupted *intensica*, Curran.
Pollinose band on third segment entire, wide in the middle, narrowed laterally ... ... *aurifrons*, Villen.
44. Parafacials bare on lower third or more 46
Parafacials haired on whole length or nearly so 45
45. Third antennal segment at least four times as long as second ; front with two strong orbitals on either side ... ... *Afrosturmia orbitalis*, sp. n.
Third antennal segment not over three times as long as second ; ♂ without orbitals ... ... *setifacies*, Curran.
46. Palpi reddish except basally, distinctly broadened on the apical fourth or fifth 49
Palpi blackish or brown, usually not strongly broadened apically ... 47
47. Sexual patch at most reaching to the lateral margin, noticeably thin ... 48
Sexual patch large and dense, extending slightly on to the dorsum ; middle tibiae with one long and one short antero-dorsal bristle *fuscicosta*, Curran.
48. Parafacials entirely without hairs ; middle tibiae with two strong antero-dorsal bristles ... ... *melita*, Curran.
Parafacials with many hairs, golden yellowish ; middle tibiae with only one strong antero-dorsal bristle ... ... *congolensis*, Villen.
49. Sexual patch very large and moderately dense 50
Sexual patch rather small, rather thin and not well defined... *congolensis*, Villen.
50. Costal border broadly brown ... ... *grandis*, Curran.
Wings cinereous hyaline, costal border not brown ... ... *abana*, sp. n.

Key to Females of Sturmia.

1. Sternopleurals 2–1–1, the third nearer the fourth than the first ... 2
Sternopleurals 3, if four are present not arrange 2–1–1, or if so, the third is nearer the first than the fourth... 23
2. Parafacials bare... 13
Parafacials setose on upper third or more 3
3. Parafacials bare on lower half or more 4
Parafacials with sparse hair on whole length ... ... *femineum*, Curran.
4. Third vein with a single basal seta 5
Third vein with three basal setae ... ... *rex*, Curran.
5. With a row or at least half a row of setae behind the occipital cilia ... 8
With only a few scattered setae behind the occipital cilia on the upper half of the front 6
6. Front about four-fifths as wide as either eye 7
Front as wide as either eye ... ... *laxa*, Curran.
7. Ocellar triangle strongly ochreous ... ... *zonata*, Curran.
Ocellar triangle with slight yellowish tinge ... ... *partitor*, sp. n.
8. Parafacials not or only slightly narrowing below, where they are as wide as the third antennal segment 9
Parafacials conspicuously narrowing below, much narrower below than the third antennal segment... 11

9. Arista thickened on less than the basal half 10
Arista thickened on more than the basal half ... ... *dilabida*, Villen.
10. Palpi black ... ... **ugandana*, Curran.
Palpi reddish ... ... **gilvoides*, sp. n.
11. Large, over 12 mm. ... ... **gilvoides*, sp. n.
Under 11 mm. 12
12. *S. gilva*, *bimaculata* and *inconspicua* come here, but I have not sufficient material to permit of study to find characters for their separation.
13. Middle tibiae with a single antero-dorsal bristle 14
Middle tibiae with two antero-dorsal bristles ... ... *atropivora*, Desv.
14. Base of third vein with a single seta 18
Base of third vein with two or more setae 15
15. Costal border not broadly brownish 16
Costal border broadly brownish on basal third ... ... *negator*, Curran.
16. Ocellars much longer and stronger than the post-ocellars 17
Ocellars not stronger than the post-ocellars (Uganda) ... ... spec. ?
17. Palpi black ... ... *completa* sp. n.
Palpi reddish (Cape) ... ... spec. ?
18. With a row or half row of setae behind the occipital cilia on upper half ... 20
Without setae behind occipital cilia on upper half 19
19. Mesonotal vittae shining, paired ... ... *masakensis*, sp. n.
Mesonotal vittae dull, not approximated to form pairs ... *munroi*, Curran.
20. At least the apical third of the third abdominal segment shining ... 21
At most the apical fourth of the third segment shining ... *pulchra*, Curran.
21. Third antennal segment narrow ... ... **lavinia*, Curran.
Third antennal segment wide ... ... *cordata*, Curran.
22. Femora black 25
Femora reddish 23
23. Parafacials bare 24
Parafacials setose on upper third ... ... *laetabilis*, Villen.
24. Parafacials twice as wide as third antennal segment ... *rufina*, sp. n.
Parafacials not one and one-half times as wide as antennae *anaphe*, sp. n.
25. Wings not broadly yellow in front on basal third 27
Wings broadly yellow in front on basal third or more 26
26. Parafacials bare ... ... *natalensis*, sp. n.
Parafacials setose on upper third ... ... *picturata*, sp. n.
27. Sternopleurals arranged 1–2 ... ... *aureiventris*, Villen.
Sternopleurals not 1–2 28
28. Middle tibiae with two or more antero-dorsal bristles 31
Middle tibiae with a single antero-dorsal bristle 29
29. Parafacials bare on lower third or more 30
Parafacials setose on practically the whole length ... ... *setifacies*, Curran.
30. Head silvery white pollinose ; sternopleurals, 1–1–1 ... *angustifrons*, Villen.
Head with pollen having yellowish tinge ; sternopleurals 2–1 *grandis*, Curran.
31. Parafacials setose below the lowest frontals... 40
Parafacials bare 32
32. Size large, over 10 mm. 34
Size small, under 9 mm. ; mesonotum never ochreous-brown pollinose ... 33
33. Wings largely brown ... ... *dorina*, n. n.
Wings cinereous hyaline ; (parafacials perhaps setose) ... **melita*, Curran.
34. Row of setae behind occipital cilia obsolete on upper fourth or more ... 36
Row of setae complete 35

*Described from opposite sex, ♀ not available.

35. Ocellars as long as median frontals ... ... *chapini*, Curran.
Ocellars not nearly as long as median frontals ... ... *arrogans*, Curran.
36. Fourth abdominal segment largely or wholly reddish 37
Fourth abdominal segment wholly black 39
37. Second abdominal segment with strong marginals 38
Second abdominal segment without long marginals (S. Nigeria) ... spec. ?
38. Hair of cheeks almost all sparse and rather coarse ... *semitestacea*, Villen.
Hair of cheeks practically all fine and short ... ... *alacris*, sp. n.
39. Mesonotum ochreous-brown pollinose ; length, 9·5 mm. (Zanzibar) ... spec. ?
Mesonotum greyish pollinose ... ... *scutellata*, Rond.
40. Second abdominal segment with pair of long, strong marginals 41
Second segment without marginals 49
41. Ocellars much shorter than median frontals 42
Ocellars much longer than median frontals (Natal) ... ... spec. ?
42. Abdomen at most with very weak metallic green reflections when viewed from behind 44
Abdomen with strong metallic green reflections from posterior view ; thorax cinnamon-brown pollinose... 43
43. Ocellars indistinct ... ... *versatilis*, Villen.
Ocellars as long as post-ocellars ... ... *vivax*, Curran
44. Thorax cinereous or greyish-ochreous pollinose 45
Thorax ochreous-brown pollinose 51
45. Mesonotal pollen dull ochreous to cinereous ; length usually over 13 mm. 46
Mesonotal pollen rather golden ochreous ; length, 11 to 12 mm. *aurifrons*, Villen.
46. Costal border broadly brown on basal half 47
Costal border at most luteous... ... ... *instabilis*, sp. n.
47. Third antennal segment little more than twice as long as the second ... 48
Third antennal segment three times as long as second ... ... spec. ?
48. Middle tibiae with three very strong antero-dorsal bristles ... *rex*, Curran.
Middle tibiae with two strong and a basal weak antero-dorsal bristle *fuscicosta*, Curran.
49. Large species, over 11 mm. in length 50
Small, under 9 mm. (Parafacials bare ?) ... ... **melita*, Curran.
50. Palpi yellow ... ... *imitator*, Curran.
Palpi brown ... ... *congolensis*, Villen.
51. Pollen of third abdominal segment occupying about the basal three-fourths of the segment, not narrowed towards the middle ... ... spec. ?
Pollen of the third segment, towards the middle occupying little more than the basal half ... ... *intensica*, Curran.

Sturmia laxa, Curran.

Sturmia laxa, Curran, Bull. Ent. Res., xvii, p. 335, 1927.

This species was described from Tanganyika and South Africa. I have additional specimens from Uganda and Nyasaland.

Sturmia zonata, Curran.

Sturmia zonata, Curran, Bull. Ent. Res., xvii, p. 336, 1927.

Originally described from Uganda and Nyasaland. The following records are new : Weenen, Natal, 28,400 ft., vi-vii.1923 (*H. P. Thomasset*) ; Namiwawa, 5.iii.1913 (*C. Mason*), ex *Prodenia litura* ; Kampala, Uganda, 10.viii.1916 (*C. C. Gowdey*).

* Described from opposite sex, ♀ not available.

Sturmia dilabida, Villeneuve.

Sturmia dilabida, Villen., Ann. S. Afr. Mus., xv, p. 478, 1916.

Ten ♂♂, one ♀, New Hanover, Natal, 16.ii.1913; ♂♀, Willow Grange, Natal, iv., v. (*R. C. Wroughton*); ♂, Durban, Natal, 3.ix.1920; 2 ♀♀, Zomba, Nyasaland (*H. S. Stannus*); ♂, Barberton, S. Africa, 21.v.1913 (*H. K. Munro*).

Sturmia ugandana, Curran.

Sturmia ugandana, Curran, Amer. Mus. Novitates, no. 258, p. 16, 1927.

♂. Hoyamba, Sierra Leone, 27.vi.1926 (*E. Hargreaves*). Originally described from Uganda and Congo.

Sturmia gilva, Hartig.

Tachina gilva, Hartig, Jahr. Fortschr. Forstwiss., i, p. 288, 1838.

I have identified this species among material from the Belgian Congo, but in view of more recent studies am not certain that the record is correct.

Sturmia partitor, sp. n.

Related to *laxa,* Curran, from which it is distinguished by the whitish pollen and shining black mesonotal vittae. There are no setulae behind the occipital cilia, thus distinguishing the species from *inconspicua,* Meigen. Black, the sides of the second abdominal segment broadly reddish on the anterior three-fourths. Length, 8 to 11 mm.

♂. *Head* white pollinose, rather silvery, the front with strong ochreous tinge, slightly more than four-fifths as wide as either eye; frontals in two rows on the lowest three-fifths, the upper two pairs stronger and reclinate; on the upper two-fifths the hair is fine and rather abundant, below coarse and sparse. Frontal vitta two-thirds as wide as either parafrontal, brownish; ocellars very poorly developed, short and hair-like; outer vertical bristles absent. Occipital pile white. Cheeks one-fifth as wide as eye-height, with fine, short pile. Vibrissae situated a little above the oral margin, two weak bristles above them. Parafacials gently narrowing below, slightly wider than the third antennal segment. Facial depression with a distinct, low median carina. Palpi reddish. Antennae black, long and moderately narrow, the third segment two and one-half times as long as the second; arista thickened on the basal half but not strongly so. The parafacials are setulose on the upper half. *Thorax* cinereous pollinose, with four moderately shining black vittae. Dorsocentrals, 3–4; sternopleurals, 2–1–1; three pairs of marginal scutellars and a weaker, cruciate pair of apicals. Scutellum reddish in ground-colour, with brownish base. *Legs* black; middle tibiae with a single antero-dorsal bristle; posterior tibiae ciliate, with a longer post-median bristle. Pulvilli elongate. *Wings* cinereous hyaline; a single strong seta on the second vein just before the furcation. *Abdominal* segments greyish pollinose on the basal half or more; on the second segment on the basal four-fifths laterally, at the middle on about the basal two-fifths; on the third segment on about the basal two-thirds and on the fourth on less than the basal half, the apices of the segments shining black. First and second segments each with a pair of weak, short marginals, third and fourth each with a row of strong marginals, the latter with scattered weaker discals on the apical half. Hair appressed except on the fourth segment. Third segment with a large, cordate sexual patch on either side of the lower portion, the hair rather long and strong.

♀. Front about three-fourths as wide as either eye; two pairs of orbitals; ocellars slightly stronger; outer verticals half as long as verticals; pulvilli short; fourth segment without marginals but with short, rather stout discals scattered over the whole surface.

Type ♂, Bloemfontein, O.F.S., 3.ii.1915 (*J. C. Faure*), in collection of the Division of Entomology, Pretoria; allotype ♀, Port Shepstone, Natal, 15.viii.1920 (*H. K. Munro*), in Munro Collection. Paratypes: ♂♀, Pretoria, Transvaal, 17.iii.1915; ♂, Westminster, O.F.S., xii.1925; ♂, Hopetown, Cape, 14.v.1917; Weenen, Natal, iv.1924 (*H. P. Thomasset*).

Sturmia masakensis, sp. n.

Related to *laxa*, Curran, from which it is distinguished by the more greyish pollen and shining black vittae on the thorax. Black, the apical half of the scutellum brownish red; sternopleurals, 2–1–1. Length, 11 mm.

♂. *Head* rather silvery white, the front less thickly pollinose above, four-fifths as wide as either eye, the brownish vitta almost as wide as either parafrontal at the middle; frontals in two rows on lower half, the two upper pairs reclinate; ocellars moderately long; hair fairly abundant. Outer verticals absent; no setae behind the occipital cilia; pile white. Cheeks two-ninths as wide as eye-height, with short, fine blackish hair. Parafacials without hair, gently narrowing below, at their middle narrower than the third antennal segment. Vibrissae situated a little above the oral margin, three bristles above them. Palpi black, the apex sometimes brownish red. Antennae black, the third segment one and one-half times as long as the second. Facial depression with weak, broad, median carina. *Thorax* with the pollen greyish white, rather silvery, not dense dorsally, the vittae shining black. Dorsocentrals, 3–4; 3 pairs of marginal scutellars and a weaker, cruciate apical pair. *Legs* black; middle tibiae with a single antero-dorsal bristle, the posterior tibiae evenly ciliate; pulvilli long. *Wings* cinereous hyaline; second vein with one strong seta before the furcation. Squamae white; halteres reddish. *Abdomen* with the pollen rather thin, silvery; the broad apices of the segments shining black, in most views the apical half of the second segment appearing shining except laterally. First and second segments each with pair of short, weak marginals, the third and fourth each with a row, the fourth with bristle-like hair and scattered discals. Sexual patch large, transverse, the ends rounded, not visible from dorsal view. Hair appressed.

♀. Front slightly wider than eye, silvery white, with two or three pairs of orbitals; pollen of thorax more evident; pulvilli short.

Type ♂, allotype ♀, and 2♂ paratypes, Masaka, Uganda, 20.iii.1923, from larva of Sphingid (*H. Hargreaves*); one specimen, Aburi, Gold Coast, 1922–23 (*G. S. Cotterell*).

The paratypes are both teneral and show large reddish spots on the sides of the second abdominal segment.

Sturmia gilvoides, sp. n.

In general characters similar to *gilva*, Hartig, but much larger and with the intermediate abdominal segments deep reddish. Black, with cinereous white pollen. Length, 12 mm.

♂. *Head* silvery white pollinose, the front less thickly so, six-sevenths as wide as either eye; twelve to fourteen pairs of frontals, the upper three reclinate, the lower four below the base of the antennae, the median reclinate ones weak; a secondary row of strong frontals, the hair fine and fairly abundant; ocellars short; a complete row of setae behind the occipital cilia. Checks one-fourth as wide as eye-height, clothed with short, fine hair. Parafacials a little wider than third antennal segment, slightly narrowed below, haired on the upper third. Vibrissae situated distinctly above the oral margin, the ridges bristled on the lower third. Palpi brown, the apices very broadly reddish. Antennae black, the second segment with reddish tinge, half as long as the third; arista thickened to the middle, short pubescent. *Thorax*

grey pollinose, the vittae conspicuous, dull. Sternopleurals, 2–1–1. Hair of prosternum black. *Legs* black; middle tibiae with a single antero-dorsal bristle; pulvilli elongate. *Wings* cinereous hyaline, luteous at the base; third vein with a single basal seta. Squamae white. Halteres reddish. *Abdomen* black, the apical half of the first and the second and third segments, reddish, the median third and apical third of the third segment blackish, the basal three-fourths of the apical three segments pollinose, the pollinose bands narrowed towards the middle where there is a more or less distinct prolongation backwards; in some lights there is a slender median bare vitta. First and second segments each with a pair of weak marginals, the third and fourth each with a row, the fourth with many discals. Sexual patch rather large, dense, cordate.

Type ♂, Barberton, S. Africa, 2.v.1913 (*H. K. Munro*); in Munro Collection.

Sturmia bimaculata, Hartig.

Tachina bimaculata, Hartig, Jahr. Fortschr. Forstwiss., i, p. 286, 1838.

This species has been recorded by me from the Belgian Congo and I have seen specimens which I refer to it from other parts of Africa. However, the exact identity of the species is doubtful, and it may be that it is the same as *inconspicua*, Meigen.

Sturmia inconspicua, Meigen.

Tachina inconspicua, Meig., Beschr. Eur. Dipt., vi, p. 369, 1830.

I refer specimens from the following localities to this species: Clan Syndicate, Natal, 10–16.xii.1914; New Hanover, Natal, 12.i.1914; Bloemfontein, iv.1923 (*H. E. Irving*).

There are many records of this species from Africa, some of which probably refer to allied species. The exact identity of *inconspicua* still remains doubtful.

Sturmia munroi, Curran.

Sturmia munroi, Curran, Amer. Mus. Novitates, no. 258, p. 16, 1927.

Originally described from South Africa. I have specimens from: Aburi, Gold Coast, 1922–23 (*G. S. Cotterell*), and Kampala, Uganda, 15.v.1919 (*C. C. Gowdey*).

Sturmia cordata, Curran.

Sturmia cordata, Curran, Amer. Mus. Novitates, no. 246, p. 12, 1927.

Described from the Belgian Congo.

Sturmia lavinia, Curran.

Sturmia lavinia, Curran, Amer. Mus. Novitates, no. 258, p. 14, 1927.

Congo and Uganda.

Sturmia potina, sp. n.

Black, the scutellum and sides of the second and third abdominal segments reddish; ocellars long. Length, 10 mm.

♂. *Head* silvery white pollinose, the frontal pollen with slight yellowish tinge; front half as wide as either eye; twelve pairs of frontals, the upper pair reclinate, the lower four below the base of the antennae, the brown vitta as wide as either parafrontal; ocellars long; a row of setae behind the occipital cilia on the lower half; pile white; cheeks with sparse black hair. Parafacials narrow, a little widened above, without setae. Vibrissae situated slightly above the oral margin, the ridges bristled on the lower fourth. Palpi brown. Antennae black, narrow, reaching three-fourths the distance to the oral margin, the third segment hardly one and

one-half times as long as the second, rounded apically ; arista slender, thickened on the basal fourth, short pubescent. *Thorax* grey pollinose, the dorsum with strong ochreous tinge, the vittae paired, distinct, dull. Four pairs of marginal scutellars ; sternopleurals 2–1–1 ; prosternum with two or three bristles. *Legs* black ; middle tibiae with one antero-dorsal bristle ; pulvilli elongate. *Wings* cinereous hyaline, rather cinereous anteriorly ; third vein with two basal setae. Squamae white, with yellowish border. Halteres reddish. *Abdomen* with the lateral fourth and venter of the second and third segments reddish, the third with almost the apical half black. Basal two-thirds of the segments ochreous-grey pollinose. First segment with a pair of strong marginals, the second with two pairs of which the outer pair is weaker, the third and fourth segments each with a row, the fourth with a row of discals and a partial row towards the base. Sexual patch large, transverse, slightly visible from above, widest at its middle where it reaches to the basal fourth of the segment, its ends rounded, separated from the apex of the segment, which bears rather strong marginals.

Type ♂, Port Shepstone, Natal, 19.viii.1920 (*H. K. Munro*) ; in Munro Collection.

Sturmia pulchra, Curran.

Sturmia pulchra, Curran, Amer. Mus. Novitates, no. 246, p. 16, 1927.

Described from Uganda and Congo.

Sturmia atropivora, Desvoidy.

Sturmia atropivora, Desv., Myodaires, p. 171, 1830.

4♂♂, 2♀♀, Bloemfontein, 7.i.1921 (*H. E. Irving*) ; Nairobi, Kenya Colony, v.1911 (*T. J. Anderson*) ; Aburi, Gold Coast, 1922–23 (*G. S. Cotterell*) ; 6♂♂, 1♀, Middleburg, Cape Prov., 29.i.1925 (*B. Smit*) ; ♂♀, Barberton, S. Africa, 28.v.1914 (*H. K. Munro*) ; many specimens, Morogoro, Tanganyika, 22.v.1925, ex Saturniid (*A. H. Ritchie*).

Sturmia completa, sp. n.

Agrees well with *atropivora,* Desvoidy, but is at once distinguished by the third antennal segment being more slender, the arista thickened on the basal third only, and the sexual patches are so large as to extend far on the dorsum, where they are separated from each other by about half the width of either patch. Black, the sides of the second and third abdominal segments reddish. Length, 8 to 10·5 mm.

♂. *Head* silvery white pollinose. Front eight-elevenths as wide as either eye ; ten or eleven pairs of frontals, the upper pair reclinate, the lower three below the base of the antennae ; a secondary weaker row of frontals on lower half ; hair rather sparse ; ocellars short ; outer verticals scarcely developed ; no setae behind the occipital cilia ; cheeks a little wider than one-fifth the eye-height, clothed with short, fine hair. Parafacials slightly narrowing below, one and one-half times as wide as third antennal segment, without setae above. Vibrissae one-third the length of the second antennal segment above the oral margin, the lower third of the ridges bristled. Palpi brown. Antennae black, the third segment twice as long as the second ; arista rather slender, short pubescent. *Thorax* cinereous-white pollinose, the vittae shining, distinct, arranged in two pairs ; sternopleurals 2–1–1 ; prosternal hair black. *Legs* black ; middle tibiae with two or three antero-dorsal bristles ; posterior tibiae evenly ciliate ; pulvilli short. *Wings* cinereous hyaline ; third vein with three basal setae ; squamae white ; knob of halteres infuscated. *Abdomen* black, with cinereous white pollen, the first segment, apical fourth of the second and fourth and the third except a broad median triangle extending to the apical fourth, shining black, the pollen extending over the sides of the third segment on the basal fourth ; intermediate segments, in some lights, with an obscure, dark median vitta. The sexual patch occupies the apical three-fourths of the third segment

and extends on to the dorsum to the median fourth. First and second segments each with a pair of short marginals, the third and fourth each with a row, the fourth with two rows of short discals.

♀. Front three-fifths as wide as either eye ; two pairs of orbitals ; no secondary row of frontals ; ocellars as long as the median frontals ; one strong and one weak antero-dorsal bristle on the middle tibiae ; marginals longer ; apices of the segments more broadly shining, the pollen less sharply limited.

Type ♂, White River, Transvaal, 3.iv.1923, in the collection of the Division of Entomology, Pretoria ; allotype ♀, Barberton (*De Koop*, B.30), 6.x.1919 (*H. K. Munro*), in Munro Collection ; paratype ♂, Port Shepstone, 9.viii.1920 (*H. K. Munro*).

Sturmia rex, Curran.

Sturmia rex, Curran, Amer. Mus. Novitates, no. 246, p. 14, 1927.

Originally described from Stanleyville, Congo. Two specimens from the following localities : Kabule, Uganda, 19.vi.1909 (*C. C. Gowdey*) ; Morogoro, Tanganyika, viii.1923 (*A. H. Ritchie*).

Sturmia aurifrons, Villeneuve.

Sturmia aurifrons, Villen., Ann. S. Afr. Mus., xv, p. 475, 1916.

There are specimens from the following localities : Zomba, Nyasaland (*H. S. Stannus*) ; Monkey Bay, Lake Nyasa, Nyasaland (*Dr. W. A. Lamborn*) ; Kampala, Uganda, 17.xi.1915 (*C. C. Gowdey*) ; M'bagori's Village, edge of Kenya Forest, 12.ii.1911 (*T. J. Anderson*) ; Barberton, Farm Stentor, S. Africa, 7.vi.1925, 8.x.1919 (*H. K. Munro*).

Sturmia analis, sp. n.

Black, the abdomen mostly reddish ; wings cinereous hyaline ; parafacials setose above. Length, 10·5 mm.

♂. *Head* white, front greyish yellow, the vertex yellow pollinose. Front almost as wide as either eye ; eleven pairs of frontals, the upper two reclinate, the lower four below the base of the antennae ; a secondary row of frontals ; hair fairly long ; ocellars short. No setae behind the occipital cilia. Cheeks two-fifths as wide as eye-height, with fine hair. Parafacials not narrowed below, one and one-fourth wider than third antennal segment. Palpi reddish. Vibrissae situated moderately above the oral margin, the ridges bristled on the lower third. Antennae reddish, the third segment black, two and one-fifth longer than the second, the apex obtusely rounded. Eyes with extremely short, inconspicuous sparse hair. *Thorax* moderately yellowish-grey pollinose, the dorsum with yellowish tinge ; vittae distinct. Sterno-pleurals 2–1. Prosternum with three or four bristles. Scutellum yellow, with black base. *Legs* black, the tibiae brownish red ; middle tibiae with three antero-dorsal bristles ; posterior tibiae closely ciliate ; pulvilli elongate. *Wings* cinereous hyaline, more or less luteous basally and in front ; third vein with two basal setae. Squamae white. Halteres yellow, with brown knob. *Abdomen* reddish, the basal half of the first segment and a very broad median vitta extending to the base of the fourth and expanding slightly on the second segment and strongly on the third towards the apex, black, the pollen fairly abundant, leaving the apical fourth of the intermediate segments and the much broader apex of the fourth in the middle, bare, the pollen on the third segment very strongly narrowed laterally. Second segment with a pair, the third with a row of strong marginals ; fourth segment with a row of weak marginals and two rows of stronger discals on the apical fourth. Sexual patch large, transverse, visible from above. Genital opening closing slit-like.

Type ♂, Narok, Masai Reserve, Kenya Colony, iii. 1917 (*Capt. A. O. Luckman*) ; in the British Museum.

Sturmia negator, Curran.

Sturmia negator, Curran, Amer. Mus. Novitates, no. 258, p. 15, 1927.

The original description was based upon specimens from the Belgian Congo.

Sturmia femineum, Curran.

Sturmia femineum, Curran, Amer. Mus. Novitates, no. 258, p. 14, 1927.

The only specimen recognized is the type female from the Belgian Congo. The male has been included in the key on account of the unmistakable characters of the hairy face and the presence of four sternopleurals arranged 2–1–1.

Sturmia setifacies, Curran.

Sturmia setifacies, Curran, Amer. Mus. Novitates, no. 258, p. 12, 1927.

Described from Congo and Uganda.

Sturmia natalensis, sp. n.

Black ; abdomen castaneous reddish, with dark median vitta ; wings broadly yellowish basally and in front almost to the middle, the veins clouded with brown ; body cinereous pollinose. Length, 16 mm.

♀. *Head* white pollinose, the front and occiput more greyish. Front a little wider than either eye, with ten or twelve pairs of frontals, the lower four below the base of the antennae, the upper two reclinate ; ocellars as long as the strong orbitals ; hair coarse and sparse ; outer verticals two-thirds as long as verticals ; row of setae behind the occipital cilia, somewhat irregular above ; pile yellowish white. Cheeks three-sevenths as wide as eye-height, with sparse, coarse hair. Parafacials more than twice as wide as third antennal segment, bare. Vibrissae situated well above the oral margin, the ridges bristled on the lower third. Palpi red, moderately robust. Antennae reddish, the third segment mostly black, grey pollinose, twice as long as the second, moderately narrow, rounded apically ; arista tapering to the middle. *Thorax* cinereous pollinose, with ochreous or luteous tinge above, the vittae distinct. Humeri yellow ; scutellum deep reddish ; pleura reddish brown. Prosternal hair coarse, black. *Legs* with the tibiae and lower surface of the femora dark reddish ; middle tibiae with two very strong and one or two weak antero-dorsal bristles. *Wings* yellowish on the basal third in front, the veins clouded with brown ; third vein with three or four basal setae. Squamae whitish, with slight yellowish tinge, the border of the upper lobe pale yellowish. Halteres yellow, the knob luteous. *Abdomen* castaneous reddish, with narrow black median vitta, cinereous pollinose, the apical fourth of the segments bare, the venter with whitish pollen. First and second segments each with a pair of marginals, the third with a row ; fourth segment with row of weak marginals, two rows of strong discals and with weak discals basally.

Type ♀, Weenen, Natal, x–xi. 1925 (*H. P. Thomasset*) ; in the British Museum.

This is a very large, robust species related to *chapini*, Curran, and the male should be readily recognized by the colour of the wings, wide parafacials, etc.

Sturmia chapini, Curran.

Sturmia chapini, Curran, Amer. Mus. Novitates, no. 246, p. 11, 1927.

Described originally from the Belgian Congo. There is a single specimen from Sesse Isles, Uganda, 3. iv.1925 (*G. D. H. Carpenter*),

Sturmia picturata, sp. n.

Black, the abdomen reddish with a black median vitta on the basal three segments, the wings orange on the basal half in front, greyish beyond, the veins clouded with brown across the middle. Length, 14 mm.

♀. *Head*: face and cheeks yellow; pollen rather golden, on the face and cheeks paler. Front as wide as either eye, the vitta brown; ten pairs of frontals, the upper two reclinate, the lower three situated below the base of the antennae; hair sparse; ocellars short and weak; setae behind occipital cilia obsolete on upper half; pile whitish. Cheeks one-third as wide as eye-height, with coarse black hair. Parafacials more than twice as wide as third antennal segment, with sparse setae above. Vibrissae situated well above the oral margin, the ridges bristled on the lower fourth. Palpi reddish, broad apically. Antennae reddish, the third segment mostly black, twice as long as the second, moderately narrow; arista thickened and reddish on the basal half, pubescent. *Thorax*: pleura grey pollinose, the mesonotum greyish ochreous; humeri and scutellum yellow in ground-colour; prosternum bare. *Legs* black; tibiae reddish, the middle pair with two strong antero-dorsal bristles. *Wings*: third vein with two or three basal setae; squamae pale yellowish, the upper lobe pale orange. Halteres reddish. *Abdomen* with pale yellowish pollen, the apical fourth of the intermediate segments and the very broad apex of the fourth in the middle, shining; the median vitta rather narrow. Second segment with a pair of strong marginals, the third and fourth each with a row, the fourth with two rows of discals, that extending across the middle weak. Genital opening closing slit-like.

Type ♀, Kukedi, Uganda, iii.1921 (*Dr. G. D. H. Carpenter*); in the British Museum.

Sturmia aureiventris, Villeneuve.

Sturmia aureiventris, Villen., Wien. Ent. Zeitg., xxix, p. 252, 1920.

I have not seen this species, which was described from the Belgian Congo and is easily recognizable by the arrangement of the sternopleural bristles: 1–2.

Sturmia angustifrons, Villeneuve.

Sturmia angustifrons, Villen., Ann. S. Afr. Mus., xv, p.478, 1916.

This species is widespread in Africa but apparently not common. I have seen several specimens in addition to the following: ♂, 2♀♀, Nyasaland, from larva of a Sphingid, *Hippotion celerio* (*C. Mason*); ♂, Stanleyville, Congo; ♀, Lourenço Marques, 2.i.1922 (*C. B. Hardenberg*).

Sturmia grandis, Curran.

Sturmia grandis, Curran, Amer. Mus. Novitates, no. 246, p. 13, 1927.

I have seen only the three type specimens from Stanleyville, Congo.

Sturmia abana, sp. n.

Related to *grandis*, Curran, but at once distinguished by the wholly cinereous hyaline wings. Length, 13 mm.

♂. *Head*: face and cheeks reddish; pollen white, on the front rather yellowish; hair black. Front a little more than half as wide as either eye; fifteen pairs of frontals, the upper two reclinate, the lower four below the base of the antennae; ocellars short; no setulae behind the occipital cilia. Cheeks four-elevenths as wide as eye-height, finely haired. Parafacials twice as wide as third antennal segment, not narrowed below, with sparse setae above. Vibrissae situated well above the oral margin, the ridges bristled on the lower third. Palpi reddish. Antennae reddish, the third segment black, hardly twice as long as the second, moderately

wide ; arista thickened on the basal third. *Thorax* moderately greyish pollinose, the dorsum with strong ochreous tinge, the vittae distinct, rather shining. Scutellum brownish red. Sternopleurals 2–1. Prosternal hair black. *Legs* black ; tibiae reddish, the middle pair with four or five antero-dorsal bristles ; pulvilli elongate ; posterior tibiae closely ciliate. *Wings* cinereous hyaline, slightly yellowish basally ; third vein with four basal setae. Squamae white, with yellowish border. Halteres yellow with brown knob. *Abdomen* dark reddish, the first segment, a median vitta on the following two and the median ventral region, blackish, the basal two-thirds of the segments greyish pollinose, the pollen very strongly narrowed towards the sides of the third segment. Sexual patch large, transverse, extending a little on the dorsum. First and second segments without marginals, the third and fourth each with a row, the latter with discals on the apical fourth. Genital opening closing slit-like.

Type ♂, Morogoro, Tanganyika, viii.1923 (*A. H. Ritchie*) ; in the British Museum.

Sturmia scutellata, Desvoidy.

Nemoraea scutellata, Desv., Myodaires, p. 73, 1830.

I have seen several specimens of this species from Uganda.

Sturmia melita, Curran. .

Sturmia melita, Curran, Amer. Mus. Novitates, no. 258, p. 12, 1927.

Originally described from the Belgian Congo.

Sturmia arrogans, Curran.

Sturmia arrogans, Curran, Amer. Mus. Novitates, no. 258, p. 16, 1927.

The type specimens from Stanleyville, Congo, are the only ones seen.

Sturmia alacris, sp. n.

Black ; cinereous or greyish-ochreous pollinose ; second antennal segment, sides of the abdomen and the fourth segment, reddish. Length, 11 to 14 mm.

♂. *Head* : front five-sevenths as wide as either eye ; twelve to sixteen pairs of frontals, the upper two reclinate, the others becoming weak above, the lower four pairs situated below the base of the antennae ; no secondary row of frontals, the hair rather fine. Ocellars about as long as the post-ocellars ; outer verticals scarcely differentiated. Cheeks seven twenty-fourths as wide as eye-height, with coarse, short black hair. Parafacials wide, not narrowed below. Facial ridges setose on the lower fourth, the vibrissae situated distinctly above the oral margin. Palpi reddish. Antennae reddish, the third segment black, rather narrow, one-third longer than the second ; arista thickened on the basal half, short pubescent. Head silvery white pollinose, the front above and the upper half of the occiput more or less ochreous. Frontal vitta brown or blackish. No setae behind the occipital cilia on the upper half. *Thorax* thickly greyish pollinose, often with strong ochreous tinge, the vittae rather conspicuous. Scutellum reddish ; sternopleurals normally 2–1. *Legs* black, the tibiae more or less reddish ; middle tibiae with three or four strong antero-dorsal bristles ; posterior tibiae without a long bristle in the ciliate row ; pulvilli short. *Wings* cinereous hyaline, somewhat yellowish basally ; third vein with three basal setae. Squamae white. Halteres reddish. *Abdomen* with the first segment, posterior border of the second and third and sometimes of the fourth, and always a basal triangle on the fourth, black, the black on the second segment broad in the middle, often obsolete on the lateral half ; on the third segment occupying the posterior half and extending broadly to the base in the middle ; about the basal two-thirds of the second to fourth segments thickly cinereous or greyish yellow pollinose.

Sexual patch large and dense, transverse, its outer end sub-rectangular, the inner end rounded, almost twice as wide as long, not visible from dorsal view. First segment with pair of weak, second with pair of strong marginals, the third and fourth each with a row, the fourth with sub-marginal row of bristles and erect, coarse hair.

♀. Front as wide as either eye, with two pairs of strong orbitals ; outer verticals two-thirds as long as verticals ; no sexual patch.

Type ♂, Morogoro, Tanganyika, 12.iv.1922 (*A. H. Ritchie*) ; allotype ♀, Mlanje, Nyasaland, 23.xi. 1914 (*S. A. Neave*) ; both in the British Museum. Paratypes : 4♂♂, Morogoro, 12.iv.1922, viii. 1923, and no date (*A. H. Ritchie*) ; ♂, Abike, N. Nigeria, 8.viii.1912 (*Dr. J. W. Scott-Macfie*) ; ♀, Zomba, Nyasaland (*H. S. Stannus*).

This species is very similar to *semitestacea*, Villeneuve, but is distinguished by the shorter ocellars, the longer second antennal segment and the absence of a long bristle in the ciliate row in the posterior femora.

Sturmia semitestacea, Villeneuve.

Sturmia semitestacea, Villen., Ann. S. Afr. Mus. xv, p. 477, 1916.

♂♀, Pretoria, 13.xii.1915, 28.iii.1914 (*H. E. Irving*) ; ♂♀, Bloemfontein, 2,4.iii. 1921, ex *Bombycomorpha bifascia* (*H. K. Munro*) ; ♂,2♀♀, Griqualand West, xi.1924 (*J. Keet*) ; ♀, Kaapmuiden, 3.v.1920 ; 2♂♂, Pretoria, 28.iii.1914, 13.xii.1915 (*H. K. Munro*).

Sturmia instabilis, sp. n.

Black, the palpi, scutellum, broad sides of the abdomen, fourth segment mostly, and the tibiae, reddish ; sternopleurals 2–1 or 1–1 ; ocellars of moderate length ; pulvilli long. Length, 12 mm.

♂. *Head* with shining yellowish white pollen, the front rather brassy, hardly four-fifths as wide as either eye, the brown vitta not nearly as wide as a parafrontal ; ten or eleven pairs of frontals, the upper three reclinate, the lower three below the base of the antennae, a weak secondary row on the lower half, the hair sparse ; ocellars fairly long ; no setae behind the occipital cilia on the upper half. Cheeks three-tenths as wide as eye-height, with sparse, coarse hair below and fine hair on the upper half. Vibrissae situated well above the oral margin, the ridges bristled on the lower third. Palpi dark reddish. Antennae reaching three-fourths the distance to the oral margin, of moderate width, the third segment twice as long as the second, the second brownish red ; arista slender, thickened on the basal third *Thorax* greyish pollinose, with ochreous tinge above, but rather shining, the vittae distinct, appearing shining from most views, the pollen in front of the scutellum with a brownish tinge. Prosternum with two or three bristles. *Legs* black, the tibiae dark reddish ; middle tibiae with two long antero-dorsal bristles ; posterior tibiae long ciliate. *Wings* cinerous hyaline, somewhat luteous in front ; third vein with two basal setae. Squamae white, with pale yellow border. Halteres yellow. *Abdomen* dark reddish beyond the first segment, with a very broad median vitta (occupying almost half the dorsum) extending back to the middle of the fourth segment and expanding to form a fascia occupying the apical third of the third segment, the basal two-thirds of the segments yellowish-grey pollinose, somewhat silvery. First segment with weak, second with pair of strong marginals, the third and fourth each with a row, the fourth with a row of weak discals and very coarse, erect hair. Sexual patch large, transverse, visible from above, the ends rounded, widest at the middle where it extends to the basal fourth of the segment, separated from the apex, which bears a row of bristles.

♀. Front five-sixths as wide as either eye, whitish anteriorly ; two pairs of orbitals. Head with white pollen ; second antennal segment five-sevenths as long

as the third. Middle tibiae with three or four antero dorsal bristles on the basal half; pulvilli short. Dark abdominal fasciae a little narrower.

Type ♂ and allotype ♀, Port Shepstone, Natal, 24.viii.1920 (*H. K. Munro*); in Munro Collection. Paratypes: ♂, Barberton, S. Africa, 9.x.1919 (*Munro*); ♀, Umbilo, Durban, Natal, 30.iii.1913 (*L. Bevis*); ♀, Zomba, Nyasaland (*H. Stannus*).

The ♀ of this species is very similar to that of *aurifrons*, Villeneuve, but may be at once distinguished by the coarse hair on the lower half of the cheeks. While the hair on this part of the cheeks is slightly coarser than above, in *aurifrons* there is no striking difference.

Sturmia fuscicosta, Curran.

Sturmia fuscicosta, Curran, Amer. Mus. Novitates, no. 246, p. 10, 1927.

This species was originally described from Congo, Gold Coast, Nyasaland and Uganda.

Sturmia vulnerata, Curran.

Sturmia vulnerata, Curran, Amer. Mus. Novitates, no. 258, p. 13, 1927.

Only the type ♂ from Stanleyville, Congo, has been seen.

Sturmia imitator, Curran.

Sturmia imitator, Curran, Amer. Mus. Novitates, no. 246, p. 13, 1927.

I have a specimen from Kivuvu, Uganda, 19.viii.1913 (*C. C. Gowdey*). Originally described from the Congo.

Sturmia congolensis, Villeneuve.

Sturmia congolensis, Villen., Wien. Ent. Zeitg., xxix, p. 253, 1910.

I have seen many specimens from the Congo, some of which were determined by Dr. Villeneuve. Villeneuve has placed this species as a synonym of *imberbis*, Wiedemann, but there must be some doubt of this until the type has been re-examined in the light of our increased knowledge of the genus and the use of more characters for the differentiation of the species.

Sturmia intensica, Curran.

Sturmia intensica, Curran, Amer. Mus. Novitates, no. 246, p. 17, 1927.

Only the types from the Congo have been seen.

Sturmia vivax, Curran.

Sturmia vivax, Curran, Amer. Mus. Novitates, no. 246, p. 15, 1927.

I have seen only the type series from the Congo.

Sturmia versatilis, Villeneuve.

Sturmia versatilis, Villen., Wien. Ent. Zeitg., xxix, p. 253, 1910.

About a dozen specimens from the following localities: Kampala, Uganda, 18.viii. and 17.xi.1915; Entebbe, 29.v.1912 and 28.x.1912; Bevera, Uganda, 2.iv.1913 (all *C. C. Gowdey*); Ibadan, Nigeria, 22.v.1923 and 27.xii.1913 (*Dr. W. A. Lamborn*); and Belgian Congo.

Sturmia rufina, sp. n.

Robust; dark rusty reddish, the mesonotum blackish except on the broad lateral and posterior borders; tarsi reddish brown. Length, 14 mm.

♀. *Head*: front one-seventh wider than either eye, strongly widening anteriorly, nine pairs of frontals, the upper two reclinate, lower two below the base of the antennae; two pairs of strong orbitals; ocellars long and strong; outer verticals three-fourths as long as verticals; no setulae behind the occipital cilia on the upper half; hair of cheeks sparse, rather coarse, black. Cheeks five-twelfths as wide as eye-height. Parafacials half as wide as facial depression; vibrissae situated well above the oral margin. Antennae reaching two-thirds the distance to oral margin; third segment twice as long as second, rather ferruginous; arista slender, thickened on less than the basal half, short pubescent. Head whitish pollinose, the frontal pollen with yellow tinge. *Thorax* moderately whitish pollinose, the mesonotal pollen more yellowish. Sternopleurals 2–1. Prosternum with yellow hair. *Legs*: middle tibiae with one strong and a very weak antero-dorsal bristle. *Wings* cinereous hyaline, the veins yellow basally; third vein with four basal setae. Squamae whitish. Halteres yellow. *Abdomen* thinly cinereous pollinose, the broad apices of the segments bare and slightly darker in colour; second segment with obscure, darker median vitta. First segment with short, weak, second with pair of strong marginals, the third with a row, the fourth with the hair forming bristles, becoming weaker apically, the segment closing slit-like over the genital organs.

Type ♀, Pretoria, S. Africa, 22.x.1916 (*H. K. Munro*); in Munro Collection.

Sturmia laetabilis, Villeneuve (in litt.?).

I have several specimens from the Belgian Congo determined by Villeneuve, but have seen no description.

Sturmia anaphe, sp. n.

This pale-coloured species is distributed across the whole of tropical Africa and has been reared several times from *Anaphe* species. It will be described fully in the Entomologische Mitteilungen.

Sturmia ? dorina, nom. nov.

Sturmia ? doris Curran (not Schiner), Amer. Mus. Novitates, no. 258, p. 18, 1927.

I have seen no additional specimens of this peculiar species.

Unrecognized Species.

Sturmia imberbis, Wiedemann, Ausser. Zweifl., ii, p. 317, 1830 (*Tachina*).

Sturmia ampliceps, Karsch, Ent. Nachr., xii, p. 340, 1886 (*Masicera, Blepharipa*).

Sturmia zetterstedtii, Karsch, ibid., p. 342, 1886 (*Degeeria*).

? Sturmia idonea, Br. & Berg., Denks. Akad. Wien, lviii, p. 344, 1892 (*Argyrophylax*).

Sturmia flavohalterata, Bischof, Verh. zool.–bot. Ges. Wien., liv, p. 86, 1904 (*Polychnomyia*); Villeneuve, Ann. Soc. Ent. France, p. 503, 1917.

Sturmia insularis, Villeneuve, Rev. Zool. Afr., iv, p. 193, 1916.

Sturmia snyderi, Townsend, Ann. Mag. Nat. Hist., xvii, p. 174, 1916 (*Congochrysosoma*).

I have examined the type of this species, but it does not appear to be the same as any of the species recorded by me. However, I had no specimens for comparison at the time, so my judgment may be erroneous.

Afrosturmia, gen. nov.

Presents most of the characters of *Sturmia,* Desvoidy, but differs as follows The ♂ possesses two pairs of strong, proclinate orbitals; parafacials setose on their

whole length ; second antennal segment not over one-fourth as long as the third ; first and second abdominal segments with a pair of short marginals ; posterior tibiae closely ciliate.

Genotype : *A. orbitalis*, sp. n.

This genus is so similar to *Sturmia* that a full description is unnecessary. Whether it can be maintained as a distinct genus may be doubtful, but it seems probable that the haired parafacials and short second antennal segment will serve to separate it definitely from *Sturmia*.

Afrosturmia orbitalis, sp. n.

Black, the sides of the second and third abdominal segments reddish on the basal half ; costal border broadly brown, the veins clouded with brown. Length, 11·5 mm.

♂. *Head* greyish-yellow pollinose, the front rather golden. Front nine-thirteenths as wide as either eye, moderately widening anteriorly ; nine pairs of frontals, the upper two reclinate, the lower three situated below the base of the antennae ; two pairs of strong orbitals situated above the middle of the front ; hair sparse below, more abundant above ; ocellars short and weak ; row of setae behind the occipital cilia entire. Cheeks three-elevenths as wide as eye-height. Parafacials slightly wider than third antennal segment, haired on their whole length. Vibrissae situated almost level with the oral margin, the ridges bristled on the lower sixth. Palpi reddish. Antennae black, reaching the lowest sixth of the face, the third segment five times as long as the second, rather broad, with subparallel sides, the apex obtusely rounded ; arista tapering to the middle, pubescent. *Thorax* grey pollinose, the dorsum more or less ochreous, the vittae fairly distinct. Dorso-centrals, 3–4 ; sternopleurals, 2–1 ; 5 pairs of marginal scutellars, the apical pair cruciate, and a pair of discals. Prosternum haired. Propleura bare. Infra-squamal setulae absent. *Legs* black ; middle tibiae with two strong antero-dorsal bristles ; posterior tibiae closely ciliate ; pulvilli elongate. *Wings* brown basally and in front to beyond the middle, the veins narrowly clouded ; third vein with two basal setae. Squamae white, with yellow border. Halteres reddish, with brown knob. *Abdomen* with the basal three-fifths of the second to fourth segments cinereous pollinose, the pollen narrowed laterally on the third segment. First and second segments each with a pair of short marginals, the third with a strong, the fourth segment with a weak row, the fourth with a strong sub-marginal row and a weaker row of discals across the middle. Sexual patch large, thin, transverse, occupying the apical half of the segment and slightly visible from above. Genital opening not closing slit-like.

Type ♂, Ashanti, Gold Coast, 1915 (*Dr. A. Ingram*) ; in the British Museum.

SARCOPHAGIDAE.

Britea, gen. nov.

Radial vein not setulose behind basally ; lower squamal lobe bare above ; propleura and posternum bare ; infra-squamal setulae numerous ; post-scutellum distinct but not strong ; sternites all visible in their full width ; arista short plumose ; frontal vitta obsolete on upper fifth in ♂ ; parafacials haired ; body black-haired. Acrostichals 3 ·3 ; the anterior and posterior pairs of the presuturals rather weak ; dorso-centrals, 3–3 ; 1 sublateral ; posthumeral situated outside the presutural ; 2 intra- and supra-alars ; 3 pairs of marginal scutellars, the apical pair cruciate, the basal pair weak, a pair of discals ; sternopleurals, 2–1. Legs normal, pulvilli elongate. Wings rather narrow, with the apical cell ending moderately close to the wing-tip, the bend of the fourth vein sharply rounded ; posterior cross-vein sharply curved outwards and joining the fourth vein beyond the apical third of its penultimate section ; third vein with three or four basal setae ; squamae evenly rounded, not broadened. Second and third abdominal segments each with a pair of discals, the

second with a pair of erect and pair of subappressed marginals, the third and fourth segments each with row of erect marginals ; second segment with two marginals on either side. Sternites each with two or three bristles on either side. Genitalia conspicuous.

Genotype : *B. tachinoides*, sp. n.

Superficially this genus closely resembles several of the African TACHINIDAE, but the wholly visible sternites together with other characters at once indicate its position in the SARCOPHAGIDAE, subfamily CALLIPHORINAE. The shape and colouration remind one very strongly of the species described as *Succingulum mistum* by Villeneuve, as well as several species belonging to the MUSCIDAE. The abdomen is rather elongate, subcylindrical and tapering.

Britea tachinoides, sp. n.

Black, with cinereous white pollen. Length, 7·5 to 8 mm.

♂. *Head* greyish, the face rather silvery ; frontal vitta rusty brown ; seven or eight pairs of frontals ; ocellars long ; upper occipital cilia long. Palpi black. Antennae deep black, the third segment one and one-half times as long as the second, rounded apically, gently concave above ; arista short plumose, the rays half as long as the width of the third antennal segment. Face concave in profile. *Thorax* : from anterior view the mesonotum bears a narrow, sutural pale fascia, the broad sides and a broad median vitta in front of the suture and the posterior half of the post-sutural area whitish pollinose, varying in other views ; pleura greyish pollinose ; scutellum black. Hair fairly long. *Legs* with the femora thinly greyish pollinose, their extreme tips reddish. *Wings* with brownish tinge. Squamae with slight luteous tinge. Halteres reddish yellow. *Abdomen* with the second segment with the posterior fourth on the sides and venter, triangularly widening to occupy the apical two-thirds in the middle, shining black, elsewhere thinly pale pollinose ; third segment with similar markings, but the black triangle reaches only half-way to the base, and on the fourth segment it is very much smaller. The fourth segment bears an irregular row of discals.

Type ♂ and 7 ♂ paratypes, Kericho, Lumbwa District, Kenya Colony, 6,500 ft., 21.i, taken on wall of house (*C. M. Dobbs*). Types in the British Museum.

NATURAL ENEMIES OF THE PEAR LEAF-CURLING MIDGE, *PERRISIA PYRI*, BOUCHÉ (DIPT., CECIDOM.).

By J. G. Myers, Sc.D., F.E.S.,
Imperial Bureau of Entomology.

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1. Introduction.

In the summer of 1925 I was commissioned by the New Zealand Government Department of Agriculture to attend the Second Imperial Entomological Conference and afterwards to enquire in Europe into the possibilities of natural control for some nine primary pests of the Dominion. As the pear leaf-curling midge presented at the same time the most pressing and the most promising of these problems it was decided to make a personal study of this insect, as intensive as time would permit. The various natural enemies discovered having now been determined by the kindness of Dr. Ch. Ferrière, through the Imperial Bureau of Entomology, the biological data acquired are here published for the first time.

In 1925 only one natural enemy of *Perrisia pyri* was known in Europe, and this record (Marchal, 1900) was overlooked.* The obvious desideratum was a locality where the midge was abundant, and this proved by no means easy to find. Mr. J. C. F. Fryer, Director of the Pathological Laboratory of the Ministry of Agriculture, had kindly requested all his provincial officers to keep a look-out for the insect in their districts, and as a result one limited outbreak was reported in the Chelmsford district of Essex. Mr. B. Strang, the local inspector under the Ministry, kindly devoted a whole day to showing me the different infested orchards. So far as could be ascertained this was the only infestation in England.

At the beginning of July, the search was continued to France, where, as in England, the midge is scarcely regarded as a pest. The outbreaks, such as they are, seem to vary greatly both in intensity and in location every season, and apparently trustworthy reports often proved on investigation to be false alarms. I travelled to the Lyons district and found that, contrary to information received, *Perrisia* was entirely absent there. Dr. L. O. Howard, Chief of the U.S. Bureau of Entomology, went from Paris to the south of France at this time and reported it absent there also. Dr. R. C. Fisher told me of a small and apparently negligible outbreak in the Bordeaux district. This was all he had seen in extensive travels in France. Finally, alarmed at the passage of time, I decided to study an infestation in the Ecole Nationale d'Horticulture

* The statement of Miller (1926, p. 379) that Mercet (1917) had reared *Inostemma piricola*, Kieff., from this species was based on a slip in the " Review of Applied Entomology " (Ser. A, vi, p. 113, 1918), where the host was given as *Perrisia pyri* instead of as the pear-midge, *par excellence*, *Contarinia pyrivora*, Riley. Miller had not seen the original reference. *Inostemma piricola* has not been recorded from *Perrisia*.

at Versailles. This outbreak proving very much more promising than it was judged at first, in the end supplied all the material for the work. It offered the great advantage that I was able to do all the indoor work in Dr. Paul Marchal's laboratory (Station entomologique) in Paris, and to receive his advice in an investigation closely related to his own classical researches. I am very deeply indebted to M. Marchal and to MM. Vayssière and Trouvelot for their hospitality and ever-ready assistance; and to M. Pinelle for permission to work in the orchards of the Ecole Nationale d' Horticulture. I was greatly helped also by Dr. G. A. K. Marshall, and with literature by Dr. J. Waterston.

Dr. R. C. Fisher first reared the *Misocyclops* from *Perrisia* material and also, at the suggestion of the New Zealand Government Entomologist, dispatched to the Dominion some *Contarinia* material believed to be parasitised by *Inostemma piricola*; but he had had to discontinue this work just before my arrival in France. Mr. H. F. Barnes, in England, also studied *Perrisia pyri* and gave me the benefit of his knowledge of Cecidomyiids in general. To Mr. W. E. China I am indebted for determining or checking the Hemiptera.

2. The Pear Leaf-curling Midge.

The fact, now confirmed, that *Perrisia pyri* was not common in Europe and was not considered a serious pest, was full of promise for the possibilities of natural control; but it meant also that very little was on record of its occurrence and life-history in its native countries.

The life-history has been investigated in New Zealand by Miller, and I have been able to acquire further data in France. The eggs are laid in the young pear shoots between the folds of the budding foliage, and the larvae live in the rolled leaves, forming a persistent pseudo-gall and eventually blackening and killing all or part of the leaf. The full-fed larvae drop to the ground and burrow one or two centimetres in the surface soil, constructing frail cocoons of silk mixed with earth particles. In most cases the pupa leaves the cocoon entirely and comes to the surface of the ground for emergence of the adult midge.

Larvae kept in their rolled leaves under perfectly dry conditions went into a kind of aestivating state (hypnody) in which no further development occurred, but the fat-body became very yellow or orange and enormously enlarged, filling almost every interstice of the body. A similar change occurred in full-fed larvae waiting to pupate. In this state, under dry conditions. I kept larvae of various ages for over a month, whereas material maintained under moist conditions pupated and produced imagines in less than a fortnight from the date of collecting. Those kept dry for over a month proceeded with their development when removed to a moist environment. This would suggest a good method of shipping the endophagous parasitoids.

Truffaut (1912) states that there is a second generation at the end of August. My own observations, however, seem to indicate that there is a continuous series of overlapping generations throughout the season, beginning in May or even earlier (Dr. Paoli, *in litt.*, in Italy) and continuing till the cold of autumn.

Both M. Trouvelot and Dr. Paoli have seen *Perrisia pyri* in some abundance at Florence.

3. The Natural Enemies in general.

There seemed an interesting parallel between the parasitoids of *Contarinia*, as studied by Marchal, and those of *Perrisia*. Thus the former is attacked by the two Platygasterids, *Inostemma piricola*, Kieff., and *Platygaster lineatus*, Kieff., and by the Pteromalid, *Tridymus piricola*, Marchal, while the chief parasites of *Perrisia* are *Inostemma boscii*, Jur., *Misocyclops* (*Platygaster*) *marchali*, Kieff., and a Torymid, *Torymus abbreviatus*, Boh.

Miller (1926) has already published a paper on the more important of the *Perrisia* parasitoids sent to him, and has detailed the methods used in the attempt to establish *Misocyclops* in New Zealand. His "*Inostemma* sp." is *I. boscii*, his "*Platygaster* sp.", *Misocyclops marchali*, and his "Chalcidoids," *Torymus abbreviatus*.

The young pear shoots form the centre of a very interesting biocoenose. In the first place they are attractive to other phytophagous species besides *Perrisia pyri*. Small Lepidopterous larvae exploit them and are in their turn, as Ferrière (1927) suggests, the hosts of the Braconids, *Apanteles longicaudis*, Wesm., *A. xanthostigmus*, Hal., and *Meteorus ictericus*, Nees, which were either reared from rolled pear leaves or observed frequently among the young shoots. Three or four species of thrips abundant in the rolled leaves are preyed upon by the Anthocorids, *Triphleps minuta*, L., and *Anthocoris nemorum*, L., which also attack *Perrisia*. The Typhlocybid leafhoppers, *Eupteryx stellulata*, Burm., and *Alebra albostriella*, Fall., the Psyllid, *Psylla pyri*, L., and at least two species of Aphids suck the sap, and the last two are attended for their honey-dew by ants, which in their turn are "mimicked" by the Capsid bug, *Pilophorus perplexus*, D. & S., which feeds on the pear *Psylla* and is probably also the most redoubtable enemy of *Perrisia* larvae. A small, very active red mite preys upon the adult midges in the act of ovipositing, and small spiders catch in their webs, with considerable impartiality, representatives of most of the above species. The parasitoids of *Perrisia*, and the midge itself, are usually to be observed actively engaged searching or ovipositing. The Capsid bugs, *Heterotoma merioptera*, Scop., and *Megacoelum beckeri*, Fieb., are also definitely members of the complex.

4. Inostemma boscii, Jurine.

This energetic little black wasp was first observed at Versailles on 16th July, when it was ovipositing during hot and brilliant sunshine in the eggs of *Perrisia*. *Misocyclops* was busy at the same time, as were also the midges themselves. The two Platygasterids were in the proportion of perhaps one to every eight midges, while among themselves the two species seemed in about equal numbers. On most subsequent occasions, however, and especially towards the middle of August, the *Misocyclops* was much the more abundant. Both species were observed on such of the intervening dates as the weather permitted.

Inostemma takes from half a minute to more usually a minute for each oviposition. This is much slower than *Misocyclops*, but much quicker than *I. piricola* of the pear-fruit midge, which Marchal (1907) found to require a quarter or half an hour or even longer. The long period is probably associated with the much longer ovipositor in *Inostemma* than in the other genus, and this in its turn with the extraordinary dorsal horn which sheathes the ovipositor and renders *Inostemma* unique among insects.

While there is no evidence that either of the two Platygasterids ever pierce the leaf tissue as does the *Torymus* mentioned later, there was still indication in the field that *Inostemma*, as might be expected, was able to exploit much deeper-deposited eggs than could *Misocyclops*. The total reach of the latter, including abdomen and ovipositor, was observed to be much less than that of the female midge, while that of *Inostemma* is almost certainly longer than the latter.

Marchal (1906, pp. 562, 563) found *Inostemma piricola* would not or could not lay in midge eggs exposed on the surface of the bud.

Before beginning oviposition *Inostemma boscii* explores assiduously, burrowing in between the leaf buds and under the matted hairs which clothe them. While both *Inostemma* and *Misocyclops* exploit the eggs in the young buds—the usual laying-place of the midge—*Inostemma* is often seen also on the older leaves, which have begun to unroll along the midrib, but are curling more tightly on the margins as a result of midge attack. In such situations I never saw *Misocyclops*.

When *Inostemma* oviposits, as soon as the tip of the abdomen touches the point of application, the dorsal horn, which has been lying closely appressed to the dorsum of the thorax, so as to be almost invisible to the naked eye, and to the lens appearing as a mere ridge, jerks violently upwards and retains this position during the act, with a wide space between its apex and the pronotum. It is then easily visible to the unaided eye.

As in the case of *I. piricola*, so intensively studied by Marchal, this *Inostemma* apparently always oviposits in the embryonic tissue which will later form the brain of the larval midge. But in spite of repeated examinations I was not able to discover the egg until considerable development had taken place. Even then it was by no

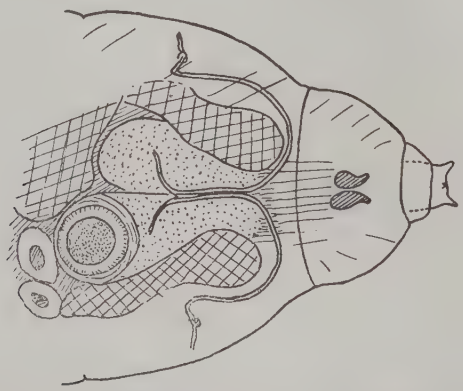

Fig. 1. Encysted egg of *Inostemma boscii*, Jur., in supra-oesophageal ganglion of larva of *Perrisia pyri*, showing also tracheae, parts of fat-body and of salivary glands, and pigment spots ; dorsal view.

means easy to distinguish, but by dint of examining many hundreds of larvae I eventually found eggs in one or other of the lobes of the supra-oesophageal ganglion. This examination was carried out day after day, but in no case was the *Inostemma* embryo found to have passed the blastula stage. All stages up to this were encysted in the brain, the egg having increased greatly in size (fig. 1). In the case of *I. piricola* Marchal found several more often than one in the same brain, but in the present species not one larva, of the hundreds examined, showed more than one such encysted egg. I think this is a constant difference ; but the final result is the same in the two species, since only one *I. piricola* survives in each host larva.

Fig. 2. Mouth-parts of larva of *Inostemma boscii*, cyclopoid stage, 24 hours after bursting from the cerebral cyst.

At last, on 12th August, a midge larva was obtained with the cerebral cyst of *Inostemma* greatly enlarged and containing a larva at the primary or cyclopoid stage rendered familiar by Marchal's work. The next day the cyst burst and the cyclopoid larva wandered into the body cavity. Even before the larva emerged from the cyst. the huge curved mandibles (fig. 2) were seen to work vigorously. Occasionally one would be opened completely so that its apex was outside the outline of the body, while the other was shut like the blade of a clasp knife. By the time the larva was mounted, 24 hours after discovery, it appeared to be ensconced in the gut of the host.

No forked caudal extremity is visible in my preparation (in Faure's liquid). The mouth-parts seems nearly identical with those of *I. piricola* as figured by Marchal (1906, fig. 66). In the median line, where the closed mandibles almost meet, there is a larger brown eminence, with a smaller one on each side (fig. 2). Cephalad of these is a row of three more equal-sized brown nodules nearly as big as the first-described median one—rather larger than in Marchal's figure of the other species.

No later stages of *I. boscii* were found, nor were the adults reared from the material which produced imagines of some of the other parasitoids.

To sum up the life-history data, it seems that oviposition may occur at almost any time from the middle of July to the middle of August, but that development has apparently proceeded no further than the primary larva by the latter date. This would suggest that the later stages are passed in the wintering larvae of the host ; but such an explanation is open to many objections. On the other hand it is almost impossible that I could have missed seeing the older larvae of *Inostemma* had they been present in my material, since I had learned to detect with facility the much less conspicuous early stages.

No signs of hyperparasites were found, nor do I think it probable that any exist. Possibly, as in the case of the related species attacking *Contarinia*, *Inostemma* sometimes lays in a midge ovum containing already a *Misocyclops* (*Platygaster*) egg or *vice versa* ; but I saw no instance of this. Cases where *Torymus abbreviatus* parasitised larvae already attacked by *Inostemma* were several times observed.

The only direct enemy of *Inostemma* was a small spider which built its web on the pear shoots and seemed frequently to catch it.

Inostemma apparently needs for ovipository activity hotter weather and brighter sunshine than any of the other *Perrisia* parasitoids.

In De Gaulle's Catalogue of French Hymenoptera (Paris, 1908, p. 116) this species is recorded from *Cecidomyia brassicae*, *C. salicina* and *Cydia pomonella* (" *Carpocapsa pomonana* "). The last record is almost certainly an error. It has been copied by Sciarra, by Feytaud and by Regnier, in papers on the codling moth.

5. Misocyclops marchali, Kieff.

This was first reared from *Perrisia pyri* by Dr. Fisher in July, from infested pear leaves collected at Bordeaux. The first field observations were made at Versailles on 16th July, when it was ovipositing in company with *Inostemma*. From the latter it was not easy to distinguish in the field, although under magnification the dorsal horn and the venation of *Inostemma* prevented confusion. On that date *Misocyclops* seemed no more abundant than the other, but on most subsequent occasions the former appeared far the more plentiful. This was especially the case towards the middle of August. Thus on 11th of that month, of 30 specimens of Platygasterids collected, 27 were *Misocyclops* and only 3 *Inostemma*. On the same day, of eggs of *Perrisia* taken from pear shoots picked at random, 58 per cent. contained an egg of *Misocyclops*.

This species oviposits much more quickly than *Inostemma*, taking very regularly about ten seconds. It is more difficult to observe, owing to a certain quickness and fussiness which *Inostemma* hardly exhibits. It seems to fly aimlessly, and to settle anywhere, on stem or old leaf, whence it crawls very actively over the whole shoot. This behaviour contrasts even more strongly with that of *Torymus abbreviatus*, which flies up and down in the air as though inspecting and then goes direct to a leaf which to the observer is obviously a likely one to contain advanced midge larvae. It is difficult to avoid the impression that *Torymus* recognises such a leaf from the air.

During the actual oviposition *Misocyclops* may be observed as closely as *Inostemma*. Not only the ovipositor but the whole end of the abdomen is inserted into the bud

and between the leaf rudiments. The body is curved like a bow, the abdomen bent downwards, the insect finally standing almost on its caudal extremity. The antennae are flexed at less than a right angle and held perfectly immobile during the act.

On one occasion I saw the ovipositor actually pierce two eggs exposed on the surface. The *Misocyclops* palpated these with its antennae, then turned about, exserted the ovipositor and " felt " for the eggs. When it touched one, it manoeuvred quite a time to get the point engaged, and then rapidly pierced one end of the egg. It next " felt " for the other and pierced it with greater facility, also at an end, though this egg was lying in a different position. Again it " felt " round with the instrument, touched the first egg, but left it, touched the second and pierced this again at the same end as before. Marchal (1906, pp. 562, 563) found that *Inostemma* would not or could not lay in exposed eggs.

It seems that in the case of the *Perrisia* parasitoids the *Inostemma* specialises, as it were, in the deeper-lying midge eggs while the *Misocyclops* reaches those near the surface. Although I have never found more than one *Misocyclops* egg to one *Perrisia* egg, I once, as noticed above, saw a female pierce the same ovum twice. Marchal found that *Platygaster lineatus* often laid several eggs in one of *Contarinia*. *Perrisia* tends to deposit its eggs in clusters of six or more when it finds a suitable place. The parasitism of *Misocyclops* is also exhibited in patches, the probable reason being that a mass of midge eggs once found is exploited fully, while another is missed entirely.

Eggs of *Misocyclops* are found in the body of the midge egg and appear surprisingly large and reddish (fig. 3). In spite of the most exhaustive examination I was never able to find a single specimen at a later stage than the egg ; nor did I succeed in rearing this parasitoid from the material which supplied adults of *Torymus*. This is the more curious from the fact that Fisher reared one specimen in July from collected

Fig. 3. Developing egg of *Misocyclops marchali*, Kieff., in egg of *Perrisia pyri*, containing embryo nearly ready to hatch.

material, while Barnes bred 50 on 10th of August from English pear leaves. I examined so many larvae of the midge in July and August that it is hardly likely any later stages were missed. For the present, then, the life-history is very imperfectly known.

There were no signs of hyperparasitoids, and I saw no other enemies of this little wasp. A specimen of the red predacious mite which attacks *Perrisia* adults was seen to palpate a *Misocyclops* engaged in egg-laying, but after a somewhat lengthy examination the latter was molested no further. The spider which caught so many examples of *Inostemma* in its web seemed never to capture *Misocyclops*. Can it be that the dorsal horn of *Inostemma* helped to entangle it ?

Misocyclops will work in weather not quite favourable enough for *Inostemma*, but it requires sunshine for its full activity.

The only other recorded host of this species is *Perrisia ulmariae*, Bremi.

6. Torymus abbreviatus, Boh.

On 30th July, I first observed a beautiful metallic green Chalcidoid ovipositing in a rolled leaf containing well-grown larvae of *Perrisia pyri*. Subsequently I saw many more and was successful in rearing adults and in securing every stage except the pupal. There is very great variation in size, especially in the females, the

differences being probably of nutritional origin, since, as we shall see, the food-supply of the larva is quantitatively a matter of chance.

Whereas both the species of Platygasterids studied may be observed to alight on almost any part of the pear shoot and pursue their subsequent explorations on foot, *T. abbreviatus* flies with a curious up and down motion before the plant and usually does not alight save on a rolled leaf which appears promising for egg-laying. The whole surface of the leaf, and especially the groove between the rolled and unrolled portions, is then tapped by the very mobile antennae with feverish activity, and finally the greatly elongate ovipositor is brought into play. For this purpose the body is strongly arched and the ovipositor bent downward and forward. The sheath is placed at the point of puncture only momentarily. The stylets, forming the actual perforant weapon, pass between the hind coxae when in action and are almost invariably thrust into the convex surface of the leaf-curl. They are held at right angles from near the base of the abdomen and are forced in with great effort, until four-fifths or more of their length are buried. Meanwhile the antennae play vigorously, the stylets tend to buckle, the legs strain individually, and the whole body is exerted, being swivelled from side to side on the pivot of the stylets. All is action save for the immobile folded wings. The sheath extends straight back from the body in a position of repose, or even directly dorsally. Apparently several thrusts may be made through the same puncture. Thus in one case the stylets were almost withdrawn and then pushed in again, this manoeuvre being repeated four times, every time the direction of the instrument being varied by slewing the abdomen round—on one occasion almost at right angles to the thorax.

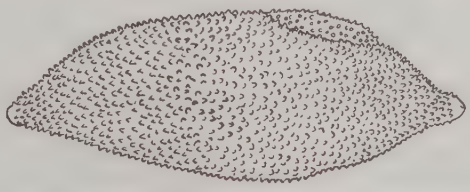

Fig. 4. Empty egg-shell of *Torymus abbreviatus*, Boh.; largest form.

A scrupulous toilet is made by the female before and between ovipositions. The antennae are rubbed with the first legs, from base to tip several times, as are also the rapidly moving mouth-parts. The third pair of legs cleans the body and the wings, which are brought down on the side of the body for the purpose and rubbed twice—one for each pair. After each operation the hind legs themselves are rubbed together.

The instrument may be inserted as often as nine times in the same leaf, taking for every time between one and two minutes. Always the egg-layer pierces the actual leaf—it was never observed to be inserted between the folds, as is the invariable procedure of the Platygasterids. The operation is performed only in fairly old rolled leaves which are likely to contain well-grown larvae of the host. The larger females seem very generally to choose older leaves with consequently larger larvae. Usually only one larva or egg of *Torymus* is present in one curled leaf, but on a single occasion two larvae were found. By what is apparently an error (Marchal's " error of instinct") on the part of the Chalcid, piercing if not actual oviposition may take place in a leaf quite empty and abandoned by midge larvae.

The relatively large egg (fig. 4) is somewhat spindle-shaped and exhibits a very granulated surface. It is deposited on the inside of the leaf curl. The larval instars (fig. 5) do not differ greatly save in size. In shape they are far more cylindrical than the midge maggots, but at the same time more thickened anteriorly, with a shining

integument through which shows conspicuously the dark-coloured gut with its rounded and blind distal extremity. Long fine hairs occur on nearly all the segments. This larva lives as an ectoparasitoid or even as a predator, destroying one maggot after another. The mouth-parts are applied to the skin of the host and the alimentary canal moves with rhythmic peristaltic waves. In the case of a full-fed midge maggot and a nearly full-grown *Torymus* grub, the former appeared appreciably shrunken after a few hours of this treatment. The period from laying of egg to completion of larval feeding is about ten days, in August at Versailles.

I was unsuccessful in observing pupation and am ignorant whether it takes place in the rolled leaves or on the ground. The larvae under direct observation all died without pupation. Yet both sexes were reared from large masses of *Perrisia* infested leaves kept on damp sand. From this material adult midges emerged in large numbers 12 to 13 days after collecting, while *Torymus* first appeared in 15 days and continued to emerge until 21 days, after which I left France. Males emerged first, the first female not appearing until five days after the first male, and on the same date as the last male. From similar material kept on dry sand *Torymus* emerged after 18 to 25 days. Washing of the sand in these cases afterwards failed to disclose any signs of pupal exuviae, but these would be very difficult to detect among the débris.

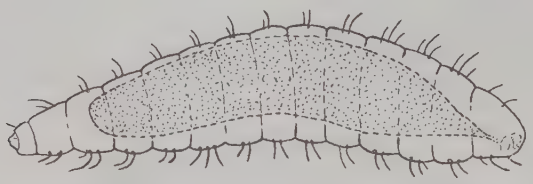

Fig. 5. Nearly full-fed larva of *Torymus abbreviatus*, Boh. ; egg laid 4th August, larva drawn 12th August from living specimen in water ; smallest form.

Copulation took place immediately the freshly emerged sexes were placed together and lasted about one minute. No examples survived captivity more than a few days.

Unlike the Platygasterids, *T. abbreviatus* oviposits actively in dull weather and even during light rain.

No hyperparasites or other enemies were observed.

The ectoparasitic larva discovered by Dr. Fisher on *Perrisia* larvae from Bordeaux probably pertained to this species, which has also been recorded from *Perrisia rosarum*, Hardy (Mayr, 1874) and *P. persicariae*, L., (Marchal, 1900). Thirty years ago Marchal (*l.c.* p. 110) also reared it from *Perrisia pyri*, but this record has been overlooked by most subsequent workers. De Gaulle (1908, p. 89) mentions as hosts *Aulacidea hieracii*, *Cynips conglomerata*, *Dryophanta disticha*, *Perrisia pini* [*? pyri*] and *Urophora cardui*.

7. Pilophorus perplexus, D. & S.

This small dark brown Capsid bug was very plentiful, as both nymphs and adults, on the pear shoots at Versailles. It " mimicked " a species of ant which attended the Aphids on the same twigs. I have seen the same association since on pears in England (Farnham Royal, Bucks.).

The members of the genus *Pilophorus* are often found, both in Europe and in North America, on plants frequented by Aphids and by the ants attending the latter for their honey-dew. The Capsid in each case, moreover, tends to resemble specifically the accompanying ant. European cases have been discussed by Butler (1923, pp. 470, 471), who quotes Hamm as stating that the ant-resemblance and

companionship of *P. cinnamopterus*, Kb., is advantageous to the bug, and Reuter and Donisthorpe as observing the Capsid preying on the ant "cows." Reuter saw it also sucking the young shoots of the host plant. The American *P. walshii*, Uhler, has been studied by Fulton (1918) and the general significance of myrmecoidy by Myers & Salt (1926). The latter paper gives a general resumé of the work of Heikertinger and others.

Pilophorus perplexus was active in all weathers and could always be seen, both nymphs and adults, with the rostrum applied to a rolled pear leaf, sucking a hidden midge larva. Broun has observed the predacious Pentatomid, *Cermatulus nasalis*, Westw., in New Zealand, feeding on larvae of the pear "slug" (*Eriocampoides limacina*, de Geer) in a somewhat similar way, piercing them through the leaf tissue from below.

There can be no doubt that, during July and August at least, *Pilophorus* caused greater mortality among the midge larvae than all other factors combined. One adult was seen on a single occasion sucking an advanced nymph of the pear *Psylla*, and sometimes rolled leaves empty of midge maggots were pierced, whether in exploration or to suck plant juices I do not know. During these two months, however, the bulk of the food seemed undoubtedly to consist of midge larvae.

In the laboratory one adult bug was able to empty a full-grown midge maggot in an hour, leaving the skin as clean as though boiled in KOH. In the field one sometimes found nothing but empty skins in a curled leaf, testifying to a local destruction of a hundred per cent.

The eggs are not known, but all other stages were collected.

Pilophorus is extremely shy, taking alarm at a distance of several feet, keeping always the stem or leaf between it and the observer and running and dodging with amazing celerity.

One would like to know how specialised in feeding-habits *Pilophorus* is at other seasons, when pear midge larvae are absent or rarer. Many groups of MIRIDAE are much more thoroughly carnivorous than is generally supposed. In this connection it is interesting that the sugar-cane leafhopper (*Perkinsiella saccharicida*, Kirk.) in Hawaii is now controlled almost solely through the agency of a Capsid of specialised feeding-habits, *Cyrtorhinus mundulus*, Bredd., which feeds on the eggs (Mr. F. Muir, in conversation). *Cyrtorhinus* is closely related to *Pilophorus*.

8. Other Enemies of the Midge.

Numbers of Hymenoptera were either bred from masses of pear midge infested leaves or frequently observed on affected parts of the plant. These have been already determined and listed by Ferrière. The only ones likely to be enemies of *Perrisia pyri* are *Eurytoma aciculata*, Ratz., *Tetrastichus brevicornis*, Nees, and *Entedon* sp. The latter especially was fairly abundant.

The small Anthocorid bug, *Triphleps minuta*, L., was reared in large numbers from the rolled leaves and was very plentiful with its nymphs on the shoots where the midge was ovipositing. Several times it was observed feeding there, probably on the eggs, but this was never quite proved. On two occasions, however, it had caught female midges in the act of egg-laying, inserting its stylets into the abdomen and sucking the insect dry in spite of the latter's violent struggles. It preyed also on small thrips.

The larger Anthocorid, *Anthocoris nemorum*, L., fed readily on *Perrisia* larvae in captivity, but was never actually seen to do so in the field, though several times observed with its rostrum inserted in rolled leaves, not piercing the wall with its stylets like *Pilophorus*, but using the opening at the tip of the roll.

A long-limbed velvety red mite, about two millimetres long, was also plentiful on the pear shoots, and was observed to seize and devour midges in the act of oviposition. It did not molest a *Misocyclops* in a similar situation. I suspect also it fed on the midge eggs.

9. Summary.

There are three main parasitoids and one very efficient predator associated with *Perrisia pyri* in France. Of these, at least during July and August, the predacious Capsid, *Pilophorus perplexus*, achieves the greatest destruction of midge larvae.

The two species of Platygasterids differ in several points of ethology from the species of the same or adjacent genera attacking *Contarinia pyrivora*. They are both egg-parasites, developing very slowly in the midge larvae during the growth of the host. Their action appears to be largely complementary, corresponding to morphological differences in the organs of oviposition. Their life-history is very imperfectly known.

Torymus abbreviatus is extremely efficient. Its eggs are laid within the curled leaf among well-grown midge maggots on which the larva lives as an ectoparasitoid. The duration and location of the pupa stadium is unfortunately not yet known.

Some half a dozen other enemies were found to play a less important part than the preceding.

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TREE-HOLES AND MOSQUITO BREEDING IN WEST AFRICA.*

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In a previous paper (Bull. Ent. Res., xvii, pp. 183–187) the writer presented a report on the mosquitos bred from material collected from dry holes in trees in the vicinity of Lagos, in Southern Nigeria. The work reported was carried out during the dry season of 1926.

The following paper gives the results of a later investigation of the mosquito breeding occurring in tree-holes during the rainy season of the same year. The main purpose of this work was to obtain additional information on the breeding habits of the yellow fever mosquito, *Aëdes (Stegomyia) aegypti*, Linn., in West Africa. It was, however, considered of additional interest to ascertain the various other species present in tree-holes during the wet season and their prevalence.

I will here take the opportunity of recording my indebtedness to Dr. I. L. Oluwole, Acting Medical Officer of Health of Lagos, for his kind co-operation and the interest he took in this investigation ; to Sanitary Inspectors J. Y. Brown and W. F. Morgan for the willing assistance they rendered ; and also to Mr. J. M. Adenibi, Senior Sanitary Inspector at Ebute Metta, for aiding in many ways. Inspector Brown took an especial interest in this work and, in addition to giving me considerable assistance, took prompt measures to have the holes in the trees cut out or filled with cement after the survey was completed in order to prevent further breeding in these places.

I wish also to extend my thanks and appreciation to Mr. H. N. Thompson, Director of Forests, Mr. L. R. Palfreman, Deputy Director Forests, and other members of the Department of Forestry at Ibadan for the identification of a number of the trees.

The Location and Species of Trees from which Samples were Collected.

During this survey water was collected, and examined for the presence of mosquito larvae, from the holes in 260 trees. Since there were often two or more holes in a tree, the total number of samples was 291. The tree, however, was taken as the unit in this survey regardless of the number of holes containing water which were present.

The trees were located at Ikoyi, Lagos, Ebute Metta and Yaba. The town of Lagos and the suburban area of Ikoyi are situated on the Island of Lagos, which is surrounded by the water of a large lagoon, but is connected by a bridge with Iddo Island from which a second bridge extends to the mainland. Ebute Metta is located near the edge of the lagoon on the mainland, while Yaba lies about three miles further inland. These four places lie more or less in the line of an obtuse angle about eight miles in length and are all included in the Township of Lagos.

The 250 trees from which samples of water were taken represented 35 species. Twenty-three of these species were identified. The remaining 12 (represented by 44 trees) were not bearing flowers, fruits, or seeds, during the period of this survey and were not classified.

* The studies and observations on which this paper is based were conducted with the support and under the auspices of the International Health Board and with the co-operation of the Health Department of Lagos, Nigeria.

TABLE I.

Species, Location, and Number of Trees from which Samples were collected.

Common Name.	Botanical Name.	Number of trees.				
		Ikoyi.	Lagos.	Ebute Metta.	Yaba.	Total.
Velvet Tamarind	*Dialium guineense* ...	43	1	6	—	50
Mango ...	*Mangifera indica* ...	2	8	—	22	32
Cashew ...	*Anacardium occidentale* ...	29	2	—	—	31
Breadfruit ...	*Artocarpus incisa* ...	—	10	10	1	21
? ...	*Hannoa klaineana*... ...	20	—	—	—	20
Flamboyant ...	*Poinciana regia*	—	1	14	2	17
Pawpaw ...	*Carica papaya*	1	4	—	—	5
Akee apple ...	*Blighia sapida*	1	—	4	—	5
Indian Almond	*Terminalia catappa* ...	—	5	—	—	5
African Walnut	*Albizzia brownii*	—	—	5	—	5
Rain Tree ...	*Pithecolobium saman* ...	—	—	4	—	4
? ...	*Vitex cienkowskii* ...	1	—	—	3	4
Indian Walnut ...	*Albizzia lebbek*	—	—	2	—	2
Dika Nut ...	*Irvingia barterii*	—	—	1	1	2
Orange ...	*Citrus aurantium*	—	—	2	—	2
Oil Palm ...	*Elaeis guineensis*	—	—	—	2	2
African Satinwood	*Zanthoxylum senegalense* ...	2	—	—	—	2
Coconut ...	*Cocos nucifera*	—	1	—	—	1
Lime ...	*Citrus acida*	—	—	1	—	1
Physic Nut ...	*Jatropha curcas*	1	—	—	—	1
Monkey Cola ...	*Cola afzelii*	1	—	—	—	1
African Star-apple	*Chrysophyllum africanum*	—	—	—	1	1
? ...	*Sterculia rhinopetala* ...	—	—	—	1	1
Coffee	*Coffea liberica*	1	—	—	—	1
Not identified (apparently 12 species) ...		36	5	2	1	44
	Totals	138	37	51	34	260

None of the trees from which samples were obtained were located at any considerable distance from a human habitation. One hundred and ninety-nine were within 100 yards of dwellings and a number of them were inside the compounds. Fifty-one were between 100 and 400 yards from houses, and ten were between 400 and 1,000 yards distant.

Factors Responsible for the Formation of Holes in Trees.

One fact quite apparent during this survey was that a considerable number of the tree-holes were indirectly caused by the hand of man. Fruit, shade and ornamental trees, and those used for firewood by the natives, were the ones in which the holes were most commonly found.

A few varieties of trees seemed to be singularly free from holes. A large percentage, however, of the trees growing in compounds or in reasonable proximity to habitations was found to have some holes, or at least to have had them previous to their being filled with cement, or other material, or cut out. Breaking off limbs while collecting fruit, trimming ornamental trees, cutting limbs of shade trees in the streets to prevent contact with telephone and electric wires, and lopping off branches for firewood, all contribute to the formation of holes.

Doubtless there is a considerable difference between various species of trees as regards development of holes. The hardness of the wood, its resistance when exposed to the air and the attacks of insects, its callus-forming qualities and rapidity of growth, all appear to be factors in the development of holes. In some trees the wounds caused by the removal of limbs apparently callus over completely before

there is much of an opportunity for decay or insects to start a hole. In others the callus appears to form only around the edge of the wound, while the centre succumbs to attacks of termites, ants or other insects, as well as decay, and a hole develops in which water may collect during the time of rains. Mango, cashew and breadfruit trees seem to have but little resistance, since holes were usually found in these species. The flamboyant also appears to be susceptible to the development of holes.

At Ikoyi a portion of the area adjacent to the Golf Course and some of the European compounds was found to be covered with a growth of small, scrubby trees and comparatively thick underbush. It was quite evident that many of the trees in this area had been cut down from time to time during clearing operations or the collection of firewood. The majority of these had apparently been cut at a height of several feet above the ground, and the stumps had sent out new growths around the edge at the top, while rot holes formed in the centre. A number of *Hannoa klaineana* with numerous holes present were found in one small section of this area, and nearly all of them consisted of new growths from stumps. The velvet tamarind, *Dialium guineense*, is abundant at Ikoyi. Many of these trees were growing inside the compounds. A large percentage of them was found to have holes, probably due to the lopping off of the limbs for firewood followed by attacks of insects and decay.

Collecting the Samples.

In searching for samples it was usually necessary for a native assistant to climb each tree in order to determine if holes were present, and, if so, whether or not they contained water. Although a large percentage of the samples was obtained at a height not exceeding fifteen feet from the ground, a few were taken at thirty feet and over.

When water was present, it was pipetted from the hole and transferred to bottles by means of a large rubber suction bulb and a piece of glass tubing. After the water in a hole had been removed and the amount measured, the inner wall of the hole was rinsed several times with clean water to remove any larvae that might have been left stranded on the side. This rinsing water was also drawn off and added to the sample. With but two exceptions all the water found in each hole was collected as the sample, regardless of whether or not the presence of larvae could be detected at the time of collection. The two holes from which all the water was not taken contained amounts larger than it was practicable to collect, since one was estimated at having over six gallons and the other at least twenty gallons. When two or more holes were found in a tree the water from each was kept separate and given a sub-number. If larvae were present, those from each hole were bred out separately. This was done in order to observe the amount of water present and also the association of breeding in each hole. All the mosquitos, however, which were bred from the two or more samples were credited to the tree as one positive collection.

Bottles of tap water were always carried along while collecting, so that the piece of glass tubing, suction bulb and funnel could be well washed after taking each sample. This prevented any larvae that might be adhering to them from being carried over to the next sample. After these bottles were emptied of the clean water they were used for holding the samples. When the latter had been transferred to breeding dishes in the laboratory the bottles were thoroughly cleaned before being refilled with clean water.

The quantity of water in the holes varied considerably, being influenced by the rainfall, size and formation of the hole, and its location in the tree, density of foliage of the tree, and various other factors. The total amount of water collected from the holes in the 260 trees was 1,583 ounces. This gave an average of more than six ounces

for each tree. The following table gives the water in the 291 holes grouped according to amount :—

TABLE II.

Approximate Amount of Water in the Holes.

Amount of water (ounces).	Less than 1	1 to 5	5 to 10	10 to 20	20 to 40	40 to 60	More than 100
Number of trees ...	45	166	45	21	10	1	3

Mosquitos Bred Out.

The samples were placed in separate dishes in the laboratory. Those in which no larvae could be discerned were observed for ten days and then discarded. When larvae were present, the samples were kept until all had pupated and been transferred to test-tubes. The mortality among the larvae and pupae was slight, being estimated at less than one per cent.

Larvae were obtained from 227, or 87·3 per cent., of the trees from which samples were taken. The adult mosquitos bred out from all the larvae totalled 12,285, this number representing 14 species.

TABLE III.

Species of Mosquitos bred from Larvae found in Tree-holes, Number and Percentage of Trees in which each Species occurred, and the Number of Adults bred out.

Species.	Number of trees.	Percentage of trees.	Number of adults.
Aëdes (*Stegomyia*) *luteocephala*, Newst.	196	75·4	6,220
Aëdes (*Stegomyia*) *aegypti*, Linn.	70	26·9	1,141
Cyathomyia fusca, Theo.	65	25·0	1,693
Aëdes (*Stegomyia*) *africanus*, Theo.	48	18·5	224
Aëdes (*Aedimorphus*) *apicoannulatus*, Edw.	43	16·5	602
Aëdes (*Stegomyia*) *apicoargentea*, Theo.	32	12·3	460
Culex (*Culiciomyia*) *nebulosa*, Theo.	18	6·9	1,569
Aëdes (*Finlaya*) *longipalpis*, Grünb.	16	6·2	264
Megarhinus (*Toxorhynchites*) *brevipalpis*, Theo ...	8	3·1	12
Aëdes (*Finlaya*) *wellmani*, Theo.	6	2·3	35
Aëdes sp.*	3	1·2	6
Aëdes (*Aëdimorphus*) *simulans*, N. & C.	2	0·8	39
Culex decens, Theo.	1	0·4	19
Aëdes (*Stegomyia*) *simpsoni*, Theo.	1	0·4	1
Total			12,285

* Apparently a new species not yet named and described.

A large percentage of the holes produced more than one species as shown in the following table :—

TABLE IV.

Number of Species occurring in the Holes.

Number of species	1	2	3	4	5	6
Number of holes	96	68	49	23	11	3

The number of larvae collected from a tree varied from 1 to 1,524. There were two holes in the tree giving this maximum number, the larger of which contained 114 ounces of water and produced 1,052 *C. nebulosa*, 289 *A. apicoannulatus*, 153 *A. luteocephala*, 17 *A. aegypti* and 3 *A. longipalpis*. The smaller hole had but four ounces of water, from which 7 *A. luteocephala* and 3 *A. aegypti* were bred out.

Occurrence of Aëdes aegypti.

Aëdes aegypti stood in second place in frequency of occurrence and fourth in number of adults bred out. As shown in Table III this species was present in the samples from 70, or 26·9 per cent. of the trees. The total number of adults of this species bred out was 1,141, giving an average of more than 16 to a tree. The largest number of adults bred from one sample was 233. This sample, consisting of 16 ounces of water, was taken from a flamboyant tree located about 50 yards from a habitation.

There was nothing in evidence to indicate that this species attempted to select only tree-holes containing clear water in which to oviposit, since on a number of occasions it was bred from samples consisting of water that was highly discoloured. Neither did there seem to be any apparent preference shown for particular kinds of trees.

It is of interest to note the distance from habitations of a number of trees in which larvae of this species were found.

TABLE V.

Distance from Habitations of Trees in which Breeding of Aëdes aegypti was found.

Distance from habitations (yards).	Less than 5	5 to 10	10 to 20	20 to 40	40 to 60	60 to 80	80 to 100	100 to 200	200 to 300	300 to 350
Number of trees	7	13	12	7	11	4	0	2	9	5

More than 71 per cent. of the holes from which *A. aegypti* larvae were obtained were less than 10 feet above the ground. The highest point at which they were taken was 22 feet.

Importance of Tree-holes in the Control of Yellow Fever.

It is difficult to form a close estimate of the importance of tree-holes as a source of *A. aegypti*. This is largely due to the fact that we have as yet no satisfactory method of expressing mathematically the amount of breeding in tree-holes, as is done for that occurring in houses.

At Ikoyi the number of trees greatly exceeds that of the houses. At Ebute Metta, where there are many shade trees growing in the streets and the majority of compounds contain fruit trees of various kinds, the houses and trees are not far from being equal in number. In the Yaba district the trees are much more numerous than the houses. In the town of Lagos the trees are relatively few compared with the houses, since some sections of the town are very closely built up with only a small number of trees present.

Naturally all the trees do not have holes, and it would be a time-consuming task that would give only indefinite results at the end to attempt a census of all the trees in order to determine the percentage having holes capable of containing water during the season of rains.

From the standpoint of yellow fever control, however, it is perhaps justifiable to place as much importance, if not more, on a tree-hole in which *A. aegypti* is breeding as on a positive water-container in a house or compound. If considered from this point of view a low percentage of houses with breeding does not necessarily signify that the actual amount of breeding has been reduced to the point ordinarily associated with the house index obtained. The breeding in the trees may be sufficient greatly to augment the index obtained by the house survey if each positive tree is given the same weight as a positive container. In other words, if control work has been carried on in a district until the breeding in houses has been reduced to give a house index of 5 per cent. and no attention has been given to the trees, the actual amount of breeding might be that which one would expect with a higher index. Naturally, this would apply only during the rainy season and to districts where many trees are present and contain holes that receive no attention.

I will here take the opportunity of stating that tree-holes in the vicinity of Lagos have apparently received attention for some years past, and at the time of writing this article the majority in Lagos and Ikoyi have been either filled with cement or cut out in order to prevent their continuance as a source of mosquitos.

Summary and Conclusions.

(1) During studies on the mosquito breeding occurring in tree-holes in the vicinity of Lagos, Nigeria, water was collected from holes in 260 trees. This number included 36 species, consisting largely of fruit trees and those used for shade and ornamental purposes.

(2) Mosquito larvae were present in samples of water taken from 227, or 87·3 per cent., of the trees.

(3) The number of adult mosquitos bred out from all larvae collected totalled 12,285, with 14 species represented.

(4) Among the several species, *Aëdes aegypti* stood second in the number of trees in which it was found and fourth in the number of adults bred out.

(5) *Aëdes aegypti* larvae were taken from holes in trees at a distance of 350 yards from the nearest habitation.

(6) The amount of breeding of *Aëdes aegypti* found occurring in tree-holes was sufficient to demonstrate their importance as a source of mosquitos of this species and the necessity for their elimination as a measure in yellow fever control.

OBSERVATIONS ON THE OVIPOSITION OF *AËDES AEGYPTI*, LINN., IN RELATION TO DISTANCE FROM HABITATIONS.*

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During the past few months the writer conducted observations to determine, first, if *Aëdes aegypti* preferred places of oviposition within habitations or those located outside with natural shelter near by, and, second, the distance from human habitations at which this species may breed. These investigations were carried out in, or near, the compound of the West African Yellow Fever Commission at Yaba, near Lagos, Nigeria.

Observations to Determine the Preference of Aëdes aegypti for Ovipositing inside or outside of Houses.

In these observations four bamboo sections (designated A, B, C and D) were used for water-containers. Each bamboo had a capacity of a little more than a pint.

Bamboo A was placed on the floor beneath a table in the corner of the kitchen, where it was in subdued light and never exposed to sunshine. The kitchen was unscreened, and the doors and windows were open from before 6 a.m. until 10 p.m. and sometimes later. It was lighted by electric lights while occupied during the evenings.

Bamboo B was placed on the floor in the corner of a room in the servants' barrack 30 yards north of the kitchen. The doors and windows of this room were unscreened and usually open until 10 or 11 p.m. There were no electric lights in this room, an oil lamp or candles being used for illumination.

Bamboo C was placed on the ground in the middle of a small, but thick clump of trees and bushes 30 yards west of the kitchen and servants' barrack. This left the relative positions of bamboos A, B and C somewhat similar to those of the points of an equilateral triangle and about 30 yards apart.

Bamboo D was placed at the base of an oil palm surrounded by long grass and low bushes. This location was from 115 to 145 yards away from bamboos A, B and C. It was 60 yards from the nearest servants' barrack and 34 yards from the animal house, where small animals for laboratory use were kept.

These four bamboos were examined every three days. When larvae were found they were transferred to breeding dishes in the laboratory and each container in which they had occurred was scrubbed thoroughly with a stiff brush and rinsed well with tap water. It was then refilled with fresh water and again placed in its proper location.

The bamboos were set out on 23rd November 1926, and the first examination was made on 26th November. It was necessary to collect the bamboos owing to

* The studies and observations on which this paper is based were conducted with the support and under the auspices of the International Health Board, Rockefeller Foundation.

the writer making a trip to Northern Nigeria, and suspend the investigation during the period from 10th January to 9th February. On the latter date they were again set out, and the observation was contined until 16th April, 1927.

During the course of this investigation the bamboos were examined 38 times. The results were rather surprising, for the larvae of *A. aegypti* were never found in Bamboos A and B, while they occurred in Bamboo C on six occasions and in Bamboo D on nine occasions. The various species of mosquitos found breeding in the bamboos were *Aëdes* (*Stegomyia*) *aegypti*, *A.* (*Stegomyia*) *apicoargentea*, *A.* (*Stegomyia*) *luteocephala*, *A.* (*Stegomyia*) *africanus*, *Culex* (*Culiciomyia*) *nebulosa* and *Culex tigripes*. The occurrence of each species is shown in Table I.

Observations to determine the Distance from Habitations that A. aegypti may oviposit.

Bamboo sections were used for water-containers in this observation also. Five of these were set out, 100 yards apart, in a more or less direct line in a savanna area adjoining the Commission compound. Bamboo No. 1 was placed 100 yards from the nearest habitation while No. 5 was 500 yards distant in the same line and farther than 500 yards from habitations in any other direction. Three of the bamboos, Nos. 2, 3 and 4, were each placed in long grass beneath bushes, while Nos. 1 and 5 were each set in the middle of a small clump of bushes. This arrangement provided for the protection of the bamboos from direct sunlight and, to some extent, from the wind.

The area in which these bamboos were placed is a large open savanna, about half a mile square and covered with a growth of long grass, small clumps of low bushes and a few trees. Two foot-paths lead across this area and a few natives pass along these daily, but seldom, if ever, does any one use them at night. A herd of cattle is occasionally grazed here for a few hours during the day, but always removed before evening. No other animals frequent this place, with the possible exception of a few small rodents, consisting mainly of bush rats.

These bamboos were examined at five-day intervals. The larvae, if present, were transferred to breeding dishes, and each bamboo from which they were removed was cleaned throughly to prevent any eggs from adhering to the inside, and then refilled with fresh water.

The bamboos were set out on 11th November 1926, and the first examination was made on 16th November. A break occurred in this observation during the period from 11th January to 9th February. The last examination was made on 15th April, when the observation was concluded.

It was remarkable to find *A. aegypti* occurring more frequently in Bamboo No. 5, at 500 yards from the nearest habitation, than in any of the other four that were located at shorter distances. The thicket in which this bamboo was placed was a fairly large one with bushes and small trees intermingled. It may have provided more shelter for the female mosquitos about to oviposit than the growth surrounding the other four bamboos. Grass fires twice swept over the part of the area in which Nos. 2, 3 and 4 were placed, and since nearly all the long grass was destroyed, this may also have been a factor in the distribution of the breeding.

The species of mosquitos that occurred in the bamboos were *Aëdes* (*Stegomyia*) *aegypti*, *A.* (*Stegomyia*) *luteocephala*, *A.* (*Stegomyia*) *africanus*, *Culex* (*Culiciomyia*) *nebulosa* and *Cyathomyia fusca*. The occurrence of each of these species in the bamboos is shown in Table II. The dates of examination that gave negative results are not included in this table ; only the dates on which larvae were found are shown.

TABLE I.

Species of Mosquitos occurring in each Bamboo.

Date.	Bamboo A. (kitchen)	Bamboo B. (servants' room).	Bamboo C. (in bushes).	Bamboo D. (in grass).
Nov. 26	*Culex nebulosa*	*Culex nebulosa*	*Culex tigripes*	—
Nov. 29	*Culex nebulosa*	*Culex nebulosa*	—	—
Dec. 2	—	*Culex nebulosa*	*Aëdes luteocephala*	—
Dec. 5	*Culex nebulosa*	*Culex nebulosa*	—	—
Dec. 11	—	*Culex nebulosa*	—	*Aëdes aegypti*
Dec. 14	—	—	*Aëdes aegypti* *Aëdes apicoargentea*	—
Dec. 17	—	—	—	*Aëdes aegypti*
Dec. 20	*Culex nebulosa*	—	—	—
Dec. 23	—	—	*Aëdes aegypti* *Aëdes apicoargentea*	—
Jan. 1	—	—	*Aëdes aegypti* *Aëdes apicoargentea*	*Aëdes aegypti*
Jan. 4	*Culex nebulosa*	—	—	—
Jan. 7	—	—	—	*Aëdes aegypti*
Jan. 10	—	—	*Aëdes apicoargentea*	—
*Feb. 15	—	—	—	*Aëdes aegypti*
Feb. 21	—	—	—	*Aëdes aegypti*
Feb. 24	—	—	*Aëdes aegypti* *Aëdes luteocephala*	—
Mar. 5	—	*Culex nebulosa*	—	—
Mar. 17	—	—	*Aëdes aegypti*	*Aëdes aegypti*
Mar. 23	—	—	—	*Aëdes aegypti*
Mar. 26	—	*Culex nebulosa*	—	—
Apr. 1	—	—	*Aëdes aegypti* *Aëdes luteocephala* *Aëdes africanus*	—
Apr. 4	*Culex nebulosa*	—	—	—
Apr. 10	—	*Culex nebulosa*	—	*Aëdes aegypti*

* Bamboos removed and observations suspended from 10th January to 9th February.

TABLE II.

Species of Mosquitos occurring in Bamboos located at from 100 to 500 yards from the nearest Habitation.

Date.	Bamboo No. 1. (100 yards)	Bamboo No. 2. (200 yards)	Bamboo No. 3. (300 yards)	Bamboo No. 4. (400 yards)	Bamboo No. 5. (500 yards)
Nov. 21	—	—	—	—	*Culex nebulosa*
Dec. 1	—	—	—	*Aëdes aegypti*	—
Dec. 11	*Aëdes aegypti*	—	—	—	—
Dec. 21	—	—	—	—	*Culex nebulosa*
Dec. 26	—	—	*Cyathomyia fusca*	—	—
Jan. 5	—	—	*Cyathomyia fusca*	—	—
Mar. 1*	—	—	—	—	*Aëdes aegypti*
Mar. 11	—	—	—	—	*Aëdes aegypti*
Mar. 16	—	*Aëdes aegypti*	—	—	*Aëdes aegypti*
Mar. 21	*Aëdes luteocephala*	—	—	—	—
Mar. 26	—	*Aëdes aegypti*	—	—	—
Mar. 31	*Aëdes luteocephala*	—	—	—	*Aëdes aegypti*
Apr. 5	— —	*Aëdes aegypti* *Aëdes luteocephala*	—	—	—
Apr. 15	*Aëdes luteocephala*	—	—	—	*Aëdes africanus* *Aëdes apicoannulatus*

* Bamboos removed and observations suspended from 10th January to 9th February.

Conclusions.

The following conclusions are drawn from the foregoing observations :—

(1) *Aëdes aegypti* manifested a preference for ovipositing in water containers located outside of houses, with bushes and trees near by to provide places of rest and concealment, as compared with containers of similar type inside of houses.

(2) *Aëdes aegypti* may oviposit in water-containers 500 yards from human habitations with no known nearer source of blood supply.

ON SOME CHALCIDOID SCALE PARASITES FROM JAVA.

By A. B. Gahan,

United States Department of Agriculture, Bureau of Entomology.

The specimens which form the basis of the following notes and descriptions were received by the writer from Mr. T. H. Colebrook Taylor, Assistant Entomologist, Fiji Islands, and were reared by him in the course of investigations looking to the introduction into the Fijis of parasites of Coccidae for the purpose of controlling the scale pests of coconut. One genus, two species and a variety are described as new.

Superfamily CHALCIDOIDEA.

Family Encyrtidae.

Comperiella bifasciata, Howard.

Three females and four males of this species were reared by Mr. Taylor from *Chrysomphalus ficus pallens,* Green, taken at Pekalongan, Java.

Comperiella unifasciata, Ishii.

Six female specimens of what appears without doubt to be this species were reared by Mr. Taylor from *Aspidiotus destructor,* Signoret, taken at Buitenzorg, Java. The species is very similar to *C. bifasciata,* Howard, but readily distinguished by the wings, which are figured by Ishii.

In addition to the above mentioned females, a very interesting gynandromorph of this species was submitted. In this specimen the left wing is nearly typically female and the abdomen shaped as in the female ; the right wing is entirely hyaline, however, as in the male of *bifasciata* ; the genitalia appear to be male, and the antennae are both more male than female, although dissimilar to some extent, the right antenna having the funicle joints two or more times as long as thick, while in the funicle of the left antenna the joints are nearly quadrate.

Chiloneurinus microphagus (Mayr).

Two females and two males from *Aspidiotus destructor,* Signoret, taken at Buitenzorg, Java, and one male from *Chrysomphalus ficus pallens,* Green, also taken in Java, were reared by Mr. Taylor.

Spaniopterus, new genus.

Resembles *Cerapterocerus,* Westwood, in shape of head, but is at once distinguished by the four-jointed funicle as well as by the wing vestiture. The antennae are much like those of *Pseudhomalopoda,* Girault, but differ in that the club is solid, and the genus may be readily separated from *Pseudhomalopoda, Plagiomerus,* Crawford, and *Homalopoda,* Howard, by the absence of lamelliform bristles on the scutellum and pronotum. Differs from *Parahomalopoda* in that the antennae are compressed and in the vestiture of forewing.

Female.—Head about as wide as thorax ; fronto-vertex flattened ; ocelli in a nearly equilateral triangle ; viewed from the side the frons prominent ; viewed from in front the head broader than high, the scrobes deep and semicircular ; antennae (fig. 1,*c*) compressed ; scape subtriangular, a little longer than broad ; pedicel subtriangular ; funicle joints all much broader than long ; club solid and about as long as funicle ; prothorax short, rounded in front ; mesoscutum a little broader than

long, finely shagreened and without grooves ; axillae apparently very nearly meeting ; scutellum as long as mesoscutum, rather narrow, finely shagreened medially, smooth laterally and at apex ; propodeum short ; legs normal ; forewings (fig. 1,*a*) well developed, the venation extending to middle of anterior margin, the marginal and stigmal veins hidden by a tuft flattened bristles and behind the submarginal vein and a little beyond its middle is a similar compact tuft of slightly longer bristles ; disk of wing marked by two narrow dark cross-bands which are united near the middle to form an irregular X-shaped figure, the dark areas caused by flattened scale-like black hairs ; discal cilia except in the crossbands normal ; the wing without an oblique hairless line and its integument uniformly subhyaline ; hind wings about half as long

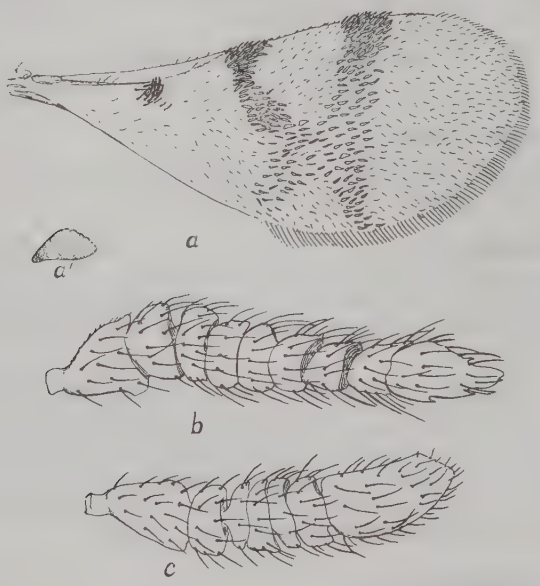


Fig. 1. *Spaniopterus crucifer*, Gahan : *a*, forewing of ♀; a^1, one of the scale-like hairs on darkened area of forewing ; *b*, antenna of ♂ ; *c*, antenna of ♀. All greatly enlarged.

as forewing, without crossbands or scale-like hairs, the venation extending two-thirds the length of wing ; abdomen as broad at base and about as long as thorax, the ovipositor not exserted ; vibrissae as long as hind tibiae.

Male.—Antennae compressed like those of female but somewhat longer and more conspicuously hairy, with the funicle 6-jointed (fig.1,*b*). Otherwise like the female.

Type of genus.—Spaniopterus crucifer, n.sp.

Spaniopterus crucifer, new species.

Female.—Length 0·51 mm. Head viewed from above about twice as broad as long, the fronto-vertex about as long as broad and weakly shagreened ; eyes bare ; face inflexed, very faintly sculptured ; pedicel somewhat broader than long, as broad as funicle joints 1, 2 and 3, subequal and each fully four times as broad as long, joint 4 about twice as broad as long ; club as broad at base as last funicle joint, tapering slightly toward apex ; scape and pedicel, as well as flagellum, uniformly clothed with rather long hairs ; mesoscutum uniformly very finely shagreened and subopaque ;

scutellum with a median area extending from base to beyond the middle sculptured like mesoscutum, otherwise smooth and shining ; basitarsus of hind tarsi short, about twice as long as broad ; basitarsus and tibial spur of middle legs subequal in length ; scale-like hairs forming the X-shaped mark on forewing, triangular, often nearly as broad at apex as long (fig. 1,a^1) ; proximal crossband originating at the marginal vein, the distal crossband touching the anterior margin of wing about half way between apex of venation and apex of wing, the two bands broadly joined ; abdomen apparently nearly smooth (the dorsum is collapsed and hence difficult to determine). Head and thorax above black or brownish black ; abdomen, ventral side of thorax, face and legs dark fuscous ; all tarsi and the apices of front and middle tibiae pale yellowish ; antennae uniformly brownish black ; wings nearly hyaline except for the scaly crossbands.

Male.—Length 0·70 mm. Antennae longer than in the female and similarly compressed ; scape a little longer than broad at apex ; pedicel about twice as broad as long ; first and second funicle joints as broad as pedicel and about three times as broad as long ; third, fourth and fifth funicle joints successively decreasing in width, the sixth equal to fifth ; club slightly broader than the last funicle joint and a little longer than the two preceding joints combined ; dark bands on the wings slightly less distinct. Otherwise like the female and except for the antennae very hard to distinguish from that sex.

Type locality.—Buitenzorg, Java.

Type.—Cat. No. 40518 U.S.N.M.

Described from three females and three males received from T. H. Colebrook Taylor with the statement that they were reared from *Aspidiotus destructor*, Signoret, collected by him at Buitenzorg, Java.

Type female, allotype male and one paratype female in the U.S. National Museum ; paratype male and female in British Museum, London ; one paratype male returned to collector. All type material in balsam.

Family Aphelinidae.

Aphelinus chrysomphali, Mercet.

Six specimens of this species were reared by Mr. Taylor from *Aspidiotus destructor*, Signoret, collected at Buitenzorg, Java. Specimens of the species were also received reared by Taylor in Fiji.

Aspidiotiphagus citrinus var. **agilior,** Berlese.

Four specimens identified as this variety were taken by Taylor at Buitenzorg, Java, and are said to have been parasitic upon *Chrysomphalus ficus pallens*, Green, and *Aspidiotus palmae*, Morgan & Cockerell.

Casca parvipennis, new species.

Superficially very similar to *Aspidiotiphagus citrinus*, Craw, and easily mistaken for that species, but the tarsi are 4–jointed, the antennae 7–jointed in the female and 8–jointed in the male. Differs from *Casca chinensis*, Howard, in that the antennal club of the female is scarcely thicker than the funicle joints and not so distinctly differentiated, the funicle joints are subequal and very nearly or quite as long as the club joints, and the wings are smaller and more pointed at apex with fewer discal cilia and proportionally somewhat longer marginal cilia.

Female.—Length 0·52 mm. ; wing expanse exclusive of marginal cilia 1·18 mm. ; greatest breadth of forewing 0·095 mm. Head as broad as thorax ; frons and vertex distinctly transversely rugulose, the latter with a very distinct oblique line or groove

behind each lateral ocellus ; ocelli in an obtuse triangle ; antennae (fig. 2,*b*) not clavate or very slightly so ; scape cylindrical ; pedicel a little thicker than the scape, shorter than the first funicle joint, a little longer than thick ; flagellum distinctly 5–jointed, the first and second joints subequal and each nearly twice as long as thick, third very slightly longer than second but a little shorter than fourth, fifth joint ovate and equal in length to the first joint ; thorax a little broader than long ; mesoscutum and scutellum apparently smooth ; parapsidal grooves distinct ; scutellum more than twice as broad as long ; forewings (fig. 2,*a*) narrow, with sparse irregularly placed discal cilia, the marginal cilia longer than the breadth of wing ; submarginal vein a little longer than marginal, with a single weak bristle a little proximad of the middle ; marginal vein with four or five stiff bristles on anterior margin ; basitarsus of middle legs nearly as long as the two following joints, the tibial spur as long as basitarsus ; hind basitarsus about equal to two following joints ; abdomen a little longer than thorax ; ovipositor, except extreme apex, concealed. Head, thorax and antennae

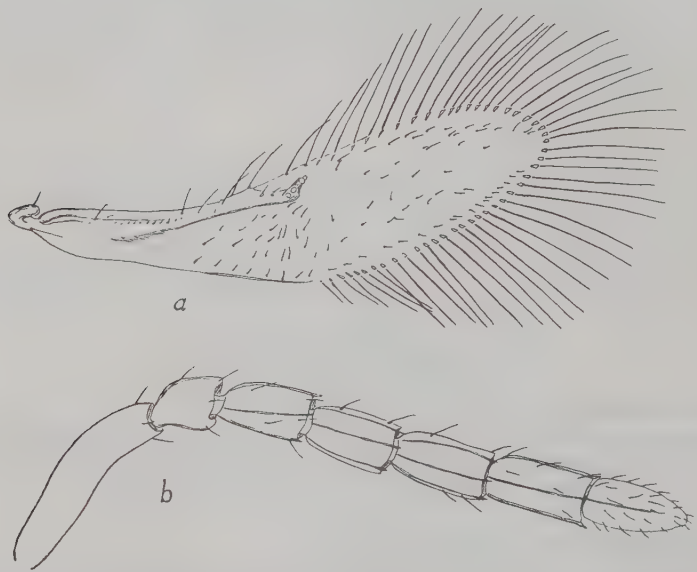


Fig. 2. *Casca parvipennis*, Gahan, ♀ : *a*, forewing ; *b*, antenna. Greatly enlarged.

pale orange yellow ; pronotum, mesonotum anteriorly and pleura fuscous ; abdomen brownish black ; wings hyaline with an indistinct fuscous band behind the marginal vein ; venation pale fuscous ; legs pallid, the hind femora very slightly dusky.

Male.—Length 0·42 mm. Antennae 8-jointed, the pedicel subequal in length to first flagellar joint, which is about twice as long as broad, second and third flagellar joints subequal to the first ; fourth, fifth and sixth slightly longer ; abdomen paler apically, and the fuscous band on forewing a little less distinct. Otherwise like the female.

Type locality.—Buitenzorg, Java.

Type.—Cat. No. 40,519 U.S.N.M.

Nine females and five males received from T. H. Colebrook Taylor and said to have been reared from *Aspidiotus destructor*, Signoret, collected by him at Buitenzorg, Java.

Type female, allotype male and seven paratypes in U. S. N. M. ; one male and one female paratype in British Museum ; three paratypes returned to collector.

Physcus varicornis, Howard, var. **intermedius,** new variety.

Like typical *varicornis* except that the abdomen is mostly yellowish beneath, and the middle and hind legs are paler. Differs from *flaviventris*, Howard, in having the first funicle joint blackish and the club pale yellowish like joint 2 and 3 of the funicle, and the abdomen dorsally is darker. *P. fijiensis*, Howard, may be distinguished by the black club of antennae.

Female.—Length 0·83 mm. Vertex and upper part of frons distinctly finely shagreened, frons below the transverse groove faintly shagreened, cheeks and temples apparently smooth ; antennae with the funicle joints subequal and each nearly twice as long as thick ; club a little broader than funicle and slightly longer than the two preceding funicle joints ; mesoscutum finely reticulate-punctate, slightly shining, the parapsidal grooves entirely absent ; scutellum much broader than long and sculptured like mesoscutum ; axillae very small and broadly separated ; propodeum and abdomen smooth ; the latter about as long as head and thorax ; ovipositor not exserted ; wings uniformly ciliated except for a small bare area on the posterior margin opposite the junction of marginal and submarginal veins ; hind basitarsus about as long as two following joints combined. Head and thorax black ; abdomen brownish yellow with broad lateral margins blackish and the dorsal middle more or less fuscous ; scape and first funicle joint blackish, the rest of antenna pale yellow ; wings hyaline ; anterior coxae, femora and tibiae and hind coxae blackish ; middle and hind femora and tibiae more or less fuscous, all trochanters, knees and tarsi pale yellowish.

Male.—Length 0·65 mm. Antennae 8–jointed, the club not thicker than funicle and not differentiated from it, all flagellar joints subequal and slightly more than twice as long as thick, the apical joint a little narrower and very slightly shorter than the preceding ; abdomen as long as thorax. Otherwise like the female.

Type locality.—Pekalongan, Java.

Type.—Cat. No. 40,520 U.S.N.M.

Five females and two males received from T. H. Colebrook Taylor from *Chrysomphalus ficus pallens*, Green, collected by him in Java.

Type female, allotype male and two female paratypes in U.S. National Museum ; one female paratype in British Museum, London ; one male and one female returned to the collector.

NOTES ON THE REACTION OF THE BREEDING PLACES OF ANOPHELINES IN MACEDONIA.

By Helen Russell, M.B., Ch.B., M.R.C.P. Edin., D.T.M.&H.

The importance of the reaction of mosquito breeding water was established by MacGregor in 1921, and since then observations have been reported from various parts of the world. In the original paper MacGregor showed that, in the laboratory, three species of English mosquitos could survive an alkalinity of pH 9·6 and died in acid water of pH 4·4, while two other species developed in pH 4·4. Later, in Mauritius, he found the local Anophelines in water ranging from pH 9·5 to pH 8·4 and rarely in places giving the reading pH 7·4 ; and maintained that the reaction of any water there was a reliable index of the presence of Anopheline larvae. Senior White, in Ceylon, found the local Anophelines in water with readings from pH 5·8 to pH 8·6 usually, and decided that on the whole the local Culicines had a more restricted range. Buxton, in Palestine, found six species of *Anopheles* in water varying from pH 9·2 to pH 7·4, and of these only one occurred in water less alkaline than pH 8. He notes that Nablus, where the water supply is unusually acid for Palestine (pH 7 to 7·5), is free from malaria. Home noted that the waters of various malaria-free parts of the tropics are slightly acid, and observed that when the Wag Water, in Jamaica, changed from alkaline to acid after heavy rains a species of *Anopheles* disappeared from it for two months. Atkins, working from known facts of the correlation of distribution of animal species and the hydrogen ion concentration of the soil and water, has sought to explain the surprising absence of malaria from some places by suggesting that the local waters may be of an unfavourable reaction for the mosquito carriers there. Williamson found that *Anopheles* breeding almost ceased in the rice fields in Malay when the acidity reached pH 6. He sought to find correlation in the distribution of plant and mosquito species, both of which depend ultimately on the chemistry of the soil. Anophelines have been found not infrequently in sea-water, which is a solution of varying alkalinity.

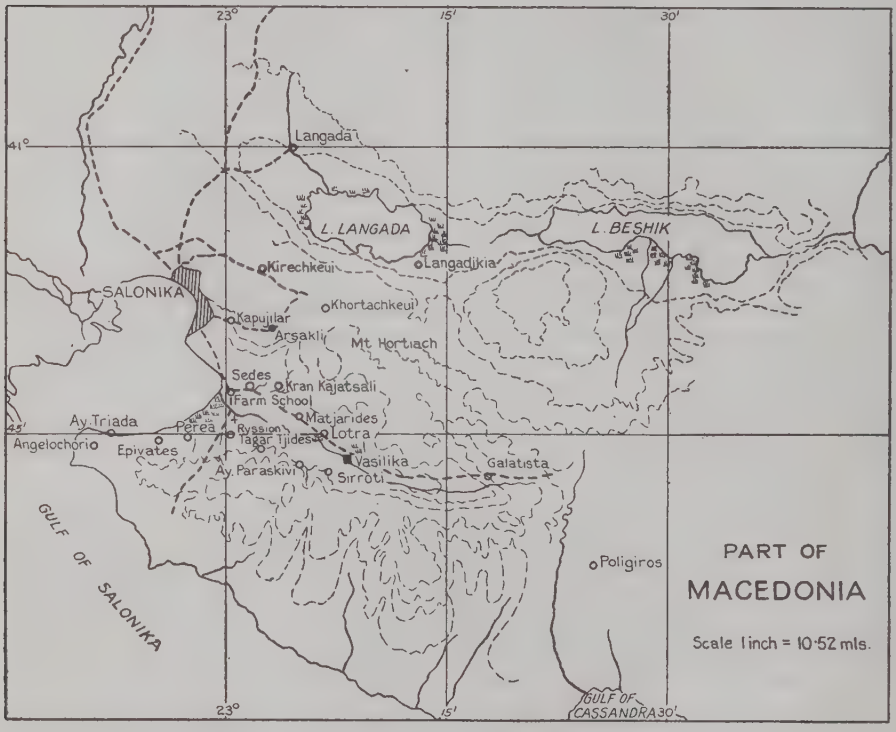
During the summer of 1926 the opportunity arose of making a few observations on the reaction of the breeding places of the common Anophelines of the Salonika and Langada sections of Macedonia. Transport and other difficulties demanded that the technique employed should be as simple as possible, and the following method was adopted. A white enamel soup-ladle was used as a dipper, and after dipping about in the water for some minutes a small quantity was tested, in the ladle, with the B.D.H. Universal Indicator ; and the observation was repeated two or three times. This indicator does not show differences of less than half a degree in the pH scale.

The Salonika and Langada sections of Macedonia are of especial interest to the student of mosquito bionomics because the reaction of the natural waters has a wide range. This probably applies to a large part of Macedonia, for the geological formation there is unusual. There are many faults in the formation, and these are marked by the appearance of hot and cold springs which arise from great depths. Three interesting places were investigated, and the reader is asked to locate them on the map before going further. First, Aya Paraskivi, on the south side of the Vasilika valley ; second Lutra, on the north side of the same valley ; and third, Lake Langada, in the Langada Beshik valley. These two valleys are separated from one another by the range in which Mount Hortiach is the highest peak. Each of the three localities lies in the line where a geological fault has been shown to occur.

Near Aya Paraskivi is the spring of a saint where the warm water bubbles out of various holes in the hillside ; it is said to have healing properties and to contain iron and sulphur. The reaction of the water at the source is pH 6·5, and the ravine down

which the water escapes is sandy. The stream was searched, and it was found that the reaction did not reach pH 8 above about a mile below the springs, and there for the first time a few Anopheline larvae were found. A species of *Culex* larva was present some yards below the source. These observations at Aya Paraskivi were unfortunately made only on one occasion, but at the time several hours were spent searching the stream, and they were made in midsummer when the other sandy hill streams were swarming with *A. superpictus*.

Lutra is a small settlement which owes its name to the presence of four warm springs. Baths have been erected over these and for a few months in summer the place is a popular health resort. There is no efficient arrangement to conduct away the water from the baths. It straggles down grassy, ill-kept ditches and channels,



and ends in a small swamp some distance below the village. When the water leaves the baths the reaction is pH 10 and it contains at least sulphur, but as it runs through the grassy channels this rapidly changes, and a few yards below the buildings pH 8 is reached. It was possible to tell almost to a yard where Anophelines would be found in the channels, always at the place where the alkalinity had fallen to pH 9·5 and below it. A species of *Culex* was found in one of the baths on one occasion.

The Langada Beshik valley is very malarious, and it is generally thought that the evil comes from the marshes along the lake margins. On several occasions the water amongst the rushes on the south shore of Lake Langada was searched for Anopheline larvae, but they were never found, In August 1926 the opportunity arose to test the water with the indicator ; it was found to give the reading pH 10, and Culicine larvae

were present but not in great numbers. Other water in the valley contained Anopheline larvae, for example, the stream at Langadikia, in which the water had the usual reaction of about pH 8·5. It is well known that summer photosynthesis lowers the hydrogen ion concentration of the sea and lake waters, but the extreme alkalinity of Lake Langada is probably due to deep springs.

The Table gives details of other breeding-places of *Anopheles* in the district. Many more observations were made and not recorded, but at no time were Anopheline larvae found in water of alkalinity above pH 9·5 or below pH 8. Culicine larvae were found at the extremes mentioned above and were almost always present with Anophelines in their natural breeding-places. It may be well to emphasise that these records are concerned with natural breeding places only. In the district under consideration Anopheline larvae were found once in an artificial collection of rain water. The vessel was an old metal barrel in the village of Peraia, a green water-weed was growing in it, and the water registered pH 9. Anopheline larvae were also present in the open cement tanks of the Greek Agricultural School, and in a shallow well in Angelochori, but these had been long neglected and were full of vegetation, so that they resembled natural pools.

TABLE.

Locality.	Breeding place.	pH.	Species.
May 1926.			
Matjarides	Overgrown field ditches, water almost still.	8 & 8·5	*A. bifurcatus*
Lutra	Grassy channels, water in motion.	8 & 8·5	*A. bifurcatus.*
Sedes	Slowly flowing, stony stream.	8·5	*A. superpictus.*
Kran Kajatsali ...	Slowly flowing, stony stream.	8·5	*A. superpictus.*
Vasilika	Irrigation ditches, almost stagnant	8	*A. bifurcatus*
Perea	Slow-flowing, sandy stream	8·5	*A. superpictus.*
June 1926.			
Sedes	Same stream.	8	*A. superpictus.*
Kran Kajatsali ...	Same stream.	8·5	*A. superpictus.*
Spring on main road.	Grassy channel, water in motion.	8	*A. maculipennis.*
Kran	Stony stream.	9·5	*A. maculipennis.*
Vasilika	Marsh.	8·5 & 9·5	*A. maculipennis.*
Matjarides ...	Road-side ditch, grassy	8·5	*A. maculipennis.*
Vasilika ...	Irrigation ditches.	9 & 9·5	*A. maculipennis* and *A. bifurcatus.*
Lutra	Grassy channels.	8·5	*A. maculipennis.*
July 1926.			
Sedes	Same stream.	8·5	*A. superpictus.*
Angelochori ...	Shallow garden well, full of vegetation.	8	*A. maculipennis.*
Perea	Same stream.	8	*A. superpictus.*
Kran Kajatsali ...	Same stream.	9·5	*A. maculipennis.*
Matjarides ...	Overgrown ditches.	9·5	*A. maculipennis.*
August 1926.			
Ryssion ...	Sandy stream.	8·5	*A. superpictus.*
Aya Paraskivi ...	Sandy stream.	8	*A. superpictus.*
Ryssion ...	Stagnant mill-stream in valley below village.	8·5	*A. superpictus.*
Greek farm school	Overgrown irrigation ditches.	8	*A. maculipennis.*
Kran Kajatsali ...	Same stream.	8	*A. superpictus.*

These very limited and scattered observations at least suggest the following:

(1). The common Anophelines of the district breed in water which is alkaline, preferring a range from about pH 9·5 to pH 8.

(2). The local Culicines are not so selective and are to be found in natural water giving readings from about pH 10 to pH 6·5.

(3). Whatever the factor in water which attracts Anophelines (be it the flora, fauna, or a chemical factor) the pH reading is sufficiently often an index of its presence and so of Anopheline larvae, in the district under consideration, to be of definite practical value to the anti-malaria worker; and the most simple technique is all that is required in the investigation.

(4). The geological formation of Macedonia is such that a study of the reaction of the natural water is likely to be of unusual interest to the student of mosquito ecology and the malaria engineer there.

I am indebted to Mr. Malcolm MacGregor for suggesting that I should note the reaction of the mosquito breeding water in the district, and to Mr. Alan Ogilvie for the use of his maps and for information on the geology of Macedonia.

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NOTES ON COTTON-STAINERS (*DYSDERCUS*) IN THE SUDAN.

By J. W. Cowland, B.A. (Cantab.) & W. Ruttledge, B.A. (Cantab.),
Assistant Government Entomologists, Sudan.

Introduction.

During the past year the writers have been engaged in a study of the cotton-stainers, *Dysdercus* spp., or as they are locally termed, " red bugs," in the provinces of the Fung and Nuba Mountains. These provinces are situated in what may be described as the northern rain-cotton belt, in which the rainfall in a normal year varies from 600 mm. to 800 mm. The following note, which is entirely of a preliminary nature, indicates the difference that apparently exists between the habits of *Dysdercus* in this region of the Sudan and those recorded in other parts of Africa where cotton growing is a well established industry.

The position of the Fung and Nuba Mountains Provinces is shown on the accompanying map. The former province is inhabited for the most part by Arabs, who have grown a certain amount of cotton for their own use and for sale to Abyssinia for many years and are familiar with the red bugs both as a cotton pest and as an associate of the tebeldi tree (*Adansonia digitata*). Recently they have been provided with seed of good quality cotton of American type and with facilities for the selling of their seed cotton for export. This has resulted in a considerable increase in the area under cotton in a good rain year and therefore an increase in the amount of damage the stainers can cause.

The natives of the Nuba Mountains are blacks, speaking dialects unrelated to Arabic. It appears unlikely that, prior to the introduction by Government of American cotton seed in 1925, they ever grew cotton as a crop, though occasional plants of a type of cotton bearing a deep red flower can be found in the villages. They, too, were familiar with the red bugs, but only as an associate of the tebeldi tree until recently, when with the appearance of American cotton the stainers have proved a serious pest.

The Species and their Distribution.

Three species of the genus *Dysdercus* occur in the region, *viz.*, *D. fasciatus*, Sign., *D. nigrofasciatus*, Stål, and *D. superstitiosus*, F. Of these, the first mentioned is the predominant species. *D. superstitiosus* is met with in small numbers in both provinces, but *D. nigrofasciatus* has not been noticed in the Nuba Mountains. Whether these three are really all distinct species or merely forms of one or two species is possibly open to doubt ; their feeding and general habits appear to be similar. Attempts to induce typical adults of *D. fasciatus* and *D. superstitiosus* to interbreed met with no success, but further work in this connection will be carried out.

It may be noted that the northern limit of *Dysdercus* in the Sudan is determined by the rainfall ; with a rainfall of less than 500 mm. they do not occur, except as occasional specimens.

Life-history and Habits.

The life-history of the stainers as observed in the laboratory does not differ in any essential detail from that already described by other writers. The nymphs, on emerging from the egg, remain clustered in the soil for two or three days and take no food until they have reached the second instar.

In considering the question of the food of *Dysdercus* in the Sudan it appears that distinction must be made between food that enables the bugs to complete their life-

cycle and food that apparently sustains the bugs for a certain time but on which they are unable to mature. In the former category, so far as is known at present, fall only tebeldi seed, kapok seed and cotton seed; while in the latter must be included a variety of plants and also such substances as animal excreta. Red bugs, in both the nymphal and the adult stages, may be seen with the proboscis inserted in the leaves and fruits of various plants and even in damp soil, but it is doubtful whether they derive very much actual nourishment from such substances and are not merely seeking moisture.

Of the food on which *Dysdercus* can breed, the seed of the tebeldi, or baobab, is undoubtedly the most important. This tree is indigenous to the Sudan and occurs very commonly in the Fung and Nuba Mountains Provinces, thriving best on sandy or gravelly soils and on the slopes of hills. It flowers during the months of April and May, before the onset of the rains, producing large oval or elongate fruits, each consisting of a hard outer shell enclosing a large number of kidney-shaped seeds, approximately 1 cm. in length, embedded in a floury white substance. From some trees fruits fall in September or shortly afterwards, but on other trees the fruits remain hanging by their stalks until the next rainy season. While hanging on the tree the shell of the fruit remains intact, but on falling, even should it not be broken by impact with the ground, it is rapidly attacked by white ants, which also devour the white floury substance in which the seeds are embedded, thus leaving the seeds exposed. It is only after the shell has been broken or devoured and the seeds freed from the white powder that the bugs are able to feed on them.

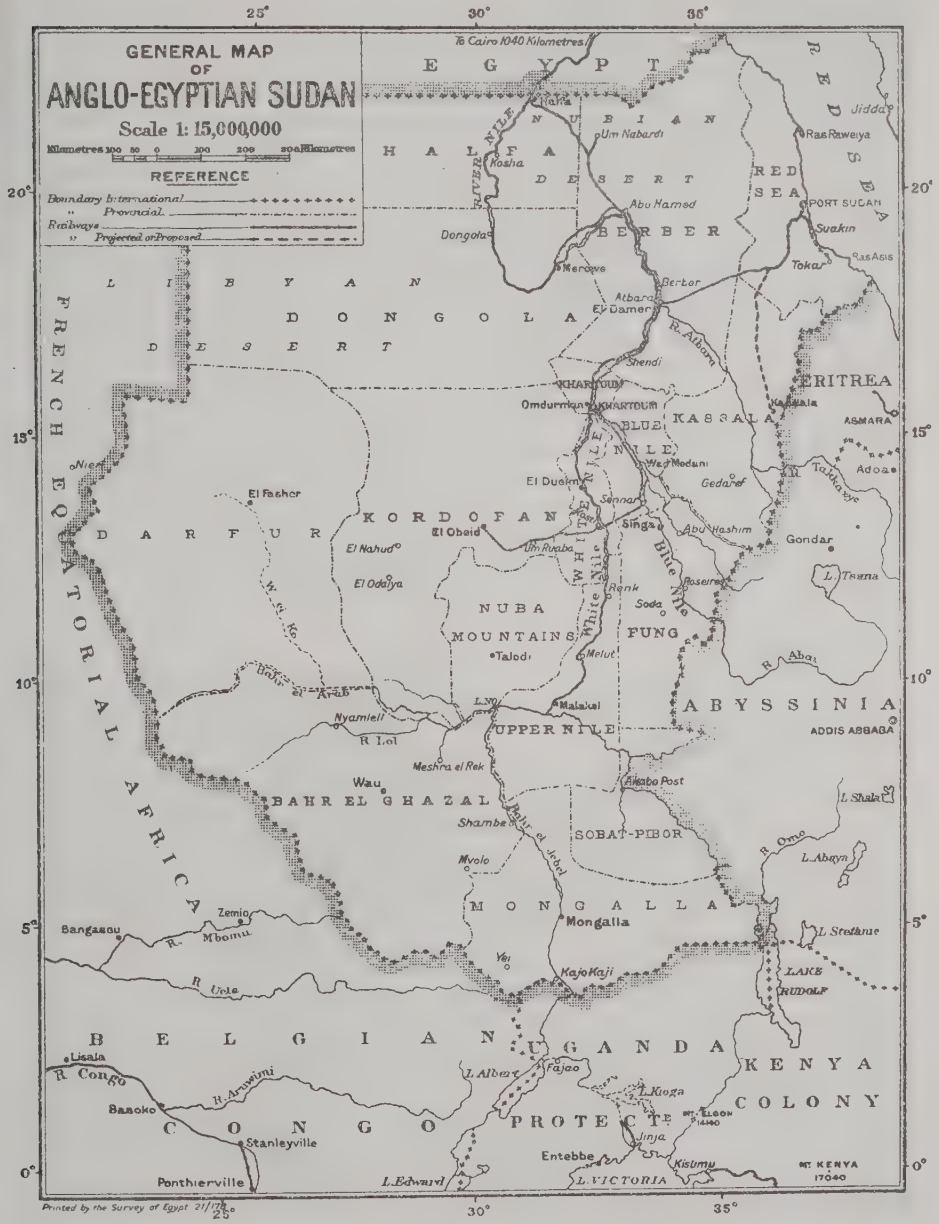
The kapok tree (*Eriodendron anfractuosum*) is not indigenous to the Sudan and is seen only in gardens and bordering roads in Government stations. As yet it need scarcely be considered as a factor of any importance in the life-history of *Dysdercus*. The fruit consists of a pod containing the white lint or silk-cotton and large numbers of spherical black seeds. The bugs have been seen feeding on these seeds only after they are exposed.

Whether cotton is really indigenous to the Sudan is possibly open to doubt, but it has been cultivated on a small scale in the Fung Province for very many years and may be considered for present purposes to have the status of a wild plant. As noted above, in the Nuba Mountains occasional plants of a red-flowered cotton may be seen growing wild, but in insufficient numbers to provide an appreciable quantity of food for *Dysdercus*.

The interior of a tebeldi seed has a very high oil content, and it is presumably on the oil that the bugs feed. The testa is approximately 0·8 mm. in thickness and intensely hard. In the case of seeds which have been exposed for some time, it would appear that the bugs are unable to penetrate the testa except through the micropyle, but they have been seen with the proboscis inserted at other points in seed newly freed from the pod.

When attacking cotton, nymphs of the second instar are usually found in open bolls, but nymphs of the later instars and adults feed on green unopened bolls, being apparently able to penetrate to the seed through the carpels.

Throughout the Fung and Nuba Mountains Provinces, *Dysdercus* appears to be essentially associated with the tebeldi. The bugs can scarcely be termed "pests" of the tebeldi, for they do not attack the tree itself, depending on fallen seeds for their sustenance. Possibly seeds on which they have fed would fail to germinate or would be found to have a diminished or inferior oil content, but as these seeds are of no value to the natives either for their own use or for sale, that is a matter of no importance. When not engaged in feeding, the bugs cluster in crevices in the trunk of the tree for shelter from the sun, but there is no evidence that the tree suffers from their presence.



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The following is a brief sketch of the history of a colony of *Dysdercus* on a tebeldi throughout the year, based on the observations of a single season. By the end of June, when the rains are well established and the humidity is high, the bugs are breeding freely, feeding on fallen seeds on the ground and at other times clustering in crevices in the trunk of the tree, under stones, and in similar places where they can obtain shelter from the sun. When the colony has become relatively strong, a tendency is evinced by a proportion of the adults to take wing and seek other feeding grounds. These emigrants usually choose either the morning or the evening in which to start their flight and are capable of travelling several miles; they have been observed on cotton distant 1½ miles from the nearest tebeldi and were then taking wing and moving on up wind. These wandering bugs do not appear to be attracted by cotton, but rather to chance on it, and having chanced on it will often stay to breed. The colony that gave rise to these wanderers persists on its tebeldi, and rapid breeding continues until the cessation of the rains in October, except for temporary checks, due possibly, as has been suggested by Pomeroy and Golding, to the direct effect on the eggs of heavy rainstorms that may wash them out and expose them to desiccation. Throughout this period of active breeding the emigration from the colony of a few individual adults may take place from time to time. When the rainy season ends and later the prevailing wind changes from the south to the north, there is an increasing mortality among the nymphs due to the drier atmosphere, the decrease in soil moisture, and the diminution of shade resulting from the tebeldi shedding its leaves. By the end of January the colony has become much reduced in numbers and from then onwards, although breeding actually continues, the bugs are no longer conspicuous clustering on the tree-trunk, but must be searched for in the soil and under rubbish at the base of the tree and inside fallen and broken tebeldi fruits. It is believed that during this period, from January to June, if the season is unusually hot and dry, many of the colonies become extinct.

Control Measures.

So far as could be ascertained, until a colony becomes fairly strong there is little tendency on the part of individuals composing it to disperse. Acting on this assumption an effort was made to prevent this dispersal by attacking the colonies on tebeldis in the neighbourhood of land under cotton. Painter's blowlamps were used for the purpose, and the results obtained were extremely promising, though it must be admitted that the season was an unusually favourable one for the carrying out of such a measure. During and immedately after the rains of 1925 *Dysdercus* were very plentiful, and the cotton crop of that year was badly stained, but, probably owing to climatic conditions during the intervening period, when the rains of 1926 started the survivors were found to be but few in number, a large proportion of the tebeldis being entirely free. Few if any emigrants went forth from colonies that had been decimated by means of blowlamps, though the complete extermination of a colony by this means was found to be impossible. Cultivators were encouraged to watch for the appearance of red bugs on their cotton and to destroy them when seen; as very few appeared on their crops this operation called for little trouble. A crop of approximately 30,000 cantars (of 100 lb.) of seed cotton was picked during the season 1926–27 in the Nuba Mountains Province, where the experiment was carried out, and the only cotton that showed signs of staining was that from a few outlying districts where no attempt was made to control *Dysdercus*. At the same time it must be emphasised that when the season started relatively few tebeldis bore colonies and that this control measure may not prove practicable in a normal year.

Summary and Conclusions.

From the above it will be seen that in the writers' opinion, based it must be admitted on but a single year's observations, the three species of *Dysdercus* (*D. fasciatus*, *D. nigrofasciatus* and *D. superstitiosus*) occurring in the northern rain-cotton

belt of the Sudan are essentially associates of the tebeldi and are not as yet other than accidental pests of cotton. By this is meant that there is no definite migration from the tebeldi to cotton, nor are wandering adults greatly attracted by cotton. The dispersal of a proportion of the adults composing a colony on a tebeldi is the natural effort on the part of the species to establish itself on other tebeldis. Emigrants from a colony that in the course of their wanderings chance on cotton may remain to breed. It is possible that when cotton has been grown in the district on a large scale for some years, the bugs, unless they are kept in check, may develop the habit of migrating definitely from the tebeldis to the cotton and, later in the season, from the cotton back to the tebeldis.

The most promising line of attack appears to be that of destroying, so far as possible, the colonies on the tebeldis during the active breeding season.

The writers' thanks are due in particular to Mr. G. F. March, Inspector of Agriculture, who in a variety of ways has rendered them the greatest assistance in their work.

THREE NEW TACHINIDAE ATTACKING INJURIOUS INSECTS IN QUEENSLAND.

By C. H. Curran.

The Tachinidae described herewith have been forwarded for determination through Dr. Guy A. K. Marshall, Director of the Imperial Bureau of Entomology, and constitute three of five species reared by Mr. E. Ballard. The types of the new species will be found in the British Museum of Natural History.

Alophora aureiventris, sp. n.

♂. Black, the reddish abdomen golden pollinose dorsally; wings blackish, with pale streaks; ♀, black, the abdomen with bands of yellowish pollen, the wings hyaline. Length, 7 to 8·5 mm.

♂. *Head* with oral margin oblique, its anterior edge situated above the lower edge of the eyes; vibrissae weak, situated well above the oral margin; face silvery; cheeks and occiput white-haired; one or two rows of hairs outside the weak frontals, which extend more than half-way to the ocelli; pollen of parafrontals with yellowish tinge; ocellar triangle black-haired, the occipital cilia black; antennae black, greyish pollinose, extending a little more than half-way to the oral margin; palpi deep reddish. *Thorax* grey pollinose, with four rather broad, sub-shining black vittae, and with a large, transverse, golden pollinose presutural spot, which is triangularly produced in the middle almost to the suture. There are two or three pairs of weak marginal scutellars and sometimes two additional very weak pairs, the apical pair of which is cruciate; sternopleurals, 1–1; pleural pile fine and whitish except on the posterior border of the mesopleura and part of the pteropleura. *Legs* with the anterior and middle femora mostly grey pollinose ventrally and posteriorly, the former white-haired behind. *Wings* blackish, with pale streaks in the costal cell, along the third and fifth veins and in the apical cell, the veins more or less yellow basally. The wings are very broad, and there appears to be considerable variation in the markings. Squamae brownish, paler on the apical half, the broad outer border of the upper lobe white. *Abdomen* blackish apically on the underside and sometimes with the apical segment and part of the preceding darkened, and with an obscure median vitta, the pollen golden dorsally, rather greyish ventrally. Hair black, pale yellowish on the lower surface.

♀. Prescutellar spot greyish; wings hyaline, the squamae paler. Abdomen black, the second and third segments with broad, interrupted, yellowish pollinose basal fasciae, the fourth segment usually wholly yellowish pollinose, the venter grey pollinose.

Type ♂, Biloela, Queensland, iv.1927; allotype ♀, Galton, Queensland, x.1926; paratypes: 2♂♂, 1♀, Brisbane, iv.1926. All but the paratype ♀ reared from a Pyrrhocorid bug, *Dysdercus sidae,* by Mr. Ballard.

Catharosia varicolor, sp. n.

Black, the ♂ with the abdomen, coxae, trochanters and base of the femora, reddish, the ♀ black except the trochanters; costal border broadly blackish or brownish on the apical two-thirds, yellowish basally. Length, 4 to 5·5 mm.

♂. *Head* with the front half as wide as either eye, moderately widening on the anterior half; head golden pollinose, the occiput much paler; frontal vitta very wide, with parallel sides; six to eight pairs of weak frontals and no hairs outside the frontal rows. Hair black, yellowish on the lower half of the occiput, coarse on the cheeks. Palpi and antennae reddish, the third segment of the latter often browned on the apical half except below; arista brown. *Thorax* moderately greyish-yellow

pollinose, with a very broad darker band immediately behind the suture. Only the posterior pair of acrostichals and dorsocentrals are present; one presutural; three or four sternopleurals in a row above; two pairs of marginal scutellars. Hair wholly black. *Legs* black, the femora usually very broadly reddish basally, rarely about half reddish, the hair wholly black; pulvilli slightly elongate. *Wings* greyish hyaline, yellowish basally, the costal border broadly blackish on the apical two-thirds; third vein ending in the wing-tip; apical cell narrow, the fourth vein very broadly rounded; posterior cross-vein joining the apical cell nearer the cross-vein than the bend; third vein without basal setulae. Squamae luteous; halteres reddish. *Abdomen* rusty reddish, shining, the apical segment and genitalia yellowish pollinose; hair black. First and second sternites rather wide, black-haired. The genitalia exposed, moderately small.

♀. Abdomen shining black, the sides of the fourth tergite strongly produced downwards, the genitalia very large, extending more than half-way to the base of the abdomen, the sternites narrower.

Type ♂, allotype ♀, and nine additional specimens from Biloela and Brisbane, Queensland, iii.–iv.1926 and 27 (*E. Ballard*), and 1♀, Biloela, ii.1927 (*G. A. Gime*), mostly reared from *Dysdercus sidae*.

Ballardia, gen. nov.

Prosternum and propleura bare; infra-squamal setulae strong; palpi about three times as long as wide, with a short apical bristle; eyes pilose; parafacials with short, rather coarse hair; bend of fourth vein with moderately long appendage, the posterior cross-vein joining the penultimate section of the fourth vein at its apical fourth; third vein with five or six strong basal setae. Head as long below as at antennae, the oral margin strongly produced; one or two bristles on the ridges above the vibrissae; facial depression shallow; front somewhat wider than either eye, gently widening anteriorly; six or seven pairs of frontals, the upper pair reclinate, the two lower situated below the base of the antennae; two pairs of strong orbitals in the ♂, the parafrontals with scattered hairs; ocellars long, proclinate; verticals long; outer verticals absent; occipital cilia long. Cheeks with sparse, coarse hair, half as wide as eye-height. Apical section of proboscis as long as oral opening, the labella moderately large; head seven-tenths as long as high; antennae reaching lowest fourth of face, the third segment three times as long as the second, widest apically, where it is subtruncate. Acrostichals and dorsocentrals, 3–3; posthumeral and posterior sublateral absent; 3 intra-alars; sternopleurals, 1–1; 4 pairs of marginal scutellars, the apical pair cruciate, and 1 or 2 pairs of discals; middle tibiae with two antero-dorsal bristles, the posterior pair with about six; pulvilli moderately small. Abdomen wider than deep (much as in *Zenillia*), the second and third segments each with a pair of discals, the fourth with a median row, the second with one pair, the third and fourth segments each with a row of marginals. Genitalia small; no sexual patch.

Genotype, the following species.

Ballardia pallipes, sp. n.

Pale rusty reddish, the occiput mostly, most of the thorax and a broad median abdominal vitta, blackish. Length, 7 mm.

♂. *Head* pale yellowish pollinose, the frontal vitta as wide as parafrontal; occipital pile yellowish, the hair elsewhere black. Palpi and antennae reddish, the third antennal segment blackish on almost the upper half except basally, the arista brown, sparsely pubescent, its penultimate segment about one and one-half times as long as wide. Hair of cheeks black; pile of eyes fairly long, pale yellowish. *Thorax* moderately yellowish-grey pollinose, the four vittae moderately distinct;

humeri, lateral margins, obscure area below the wings, and the scutellum pale yellowish red; hair black. *Legs* reddish yellow, black-haired, the apical three tarsal segments brownish. *Wings* cinereous hyaline, the veins alternately brown and luteous; third vein ending far before the wing-tip. Squamae with yellowish tinge. Halteres reddish. *Abdomen* with the black vitta occupying most of the first segment and about the median fourth of the two following and composed of a rather triangular basal spot on the fourth segment, where it does not nearly reach the apex. The black vitta bears moderately conspicuous greyish pollen, and the intermediate segments show a narrow, basal pollinose fascia, whilst the fourth is wholly conspicuously pale yellow pollinose. The lobes of the fifth sternite are about half brown. Hair black, appressed, coarse, erect on the fourth segment. The row of marginals on the third segment is much weakened on either side of the median pair of bristles.

Type ♂, Brisbane, Queensland, 19.xii.1925, from *Euxoa radians* (*E. Ballard*).

TWO NEW *SIMULIUM* FROM KASHMIR.

By F. W. Edwards.

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The two new species described below were included in collections sent to the Imperial Bureau of Entomology by Dr. P. A. Buxton, of the London School of Tropical Medicine, having been obtained in Kashmir by Major Stevenson in 1926, and again in 1927. The same collections contain examples of a third species of *Simulium* which appears indistinguishable from the European *S. equinum* (L.) Edw. Examples of this species had previously been obtained in Kashmir by Mr. F. J. Mitchell.

Simulium stevensoni, sp. n.

♀. *Head* heavily dusted with grey on occiput, frons and face. Frons moderately broad, almost parallel-sided, with a little yellowish pubescence mixed with some short dark hair. Antennae with the scape dark reddish, flagellum black; terminal segment not very sharply pointed. Palpi blackish. *Thorax* grey, without any trace of silvery reflections on shoulders. Mesonotum with three broad but not very sharply defined dark grey stripes, the middle one with traces of a blackish central line. Pubescence rather scanty, yellowish. Membranous area of pleurae with a number of soft pale hairs. *Abdomen* entirely dull, even on the terminal segments; ground-colour grey, segments 3–5* each with three blackish marks at the base, the middle one triangular and placed on the rather small tergite; segments 6 and 7 with similar markings, but less distinct, the tergites much larger. Pubescence coarse, scanty, yellowish. *Legs*: front coxae yellowish; femora brownish above, lighter beneath; tibiae blackish, with a yellowish patch on the outer side towards the base, no distinct silvery dusting; tarsi almost cylindrical, black, first segment about 7 or 8 times as long as broad. Middle coxae blackish; femora yellowish, darker at the tip; tibiae yellowish on the basal half, dark brown on the apical half; tarsi black, base of first segment yellowish. Hind coxae blackish; femora blackish, with about the basal third yellow; tibiae with nearly the basal half yellowish, the rest blackish; first tarsal segment yellow, with the apical fourth black, terminal flap very short; second tarsal segment deeply excised, base yellow, the rest black. All claws with conspicuous, sharp, sub-basal tooth. *Wings* with normal venation. Hair on stem-vein pale. No hairs on radius between stem-vein and fork. Halteres yellow. Wing-length 3–4·5 mm.

Kashmir: Chilas, near Gilgit (*Major Stevenson*); 11♀♀, mostly more or less damaged.

In Enderlein's classification this species would be referred to the genus *Odagmia* (*S. ornatum*, Mg., and related species); it is very distinct owing to the combination of striped thorax and subbasally toothed claws.

Simulium kashmiricum, sp. n.

♀. *Head* dull blackish, face grey. Front very broad, and considerably widened dorsally, densely clothed with golden yellow pubescence, mixed with some dark hair; pubescence on face similar but less abundant. Antennae with the scape reddish, flagellum black. Palpi blackish. *Thorax* blackish, without markings on integument, but rather greyer on the shoulders, pubescence rather coarse and dense, golden yellow. Membranous area of pleurae bare. *Abdomen* with the basal scale and its fringe yellow, the following segment yellow with a small dark tergite; the rest black, with coarse golden-yellow pubescence; segments 3–5 with very small tergites;

* Reckoning the basal scale as the first segment.

6–8 with very broad ones, not at all shining. *Legs*: front coxae, front femora except towards tip, basal half of middle femora, basal third or less of hind femora, basal halves of all tibiae as well as of first hind tarsal segment, and all the trochanters yellow, the rest black. Front tarsi very much flattened, the first segment about 4–5 times as long as its greatest breadth, and fringed with black hair above. Claws with subbasal tooth. Second tarsal segment with deep excision. *Wings* with normal venation; stem vein with black hair; radius hairy throughout. Halteres yellowish. Wing-length about 4 mm.

KASHMIR: Chilas, near Gilgit (*Major Stevenson*); 33♀♀, all more or less damaged. Also 9♀♀ in the British Museum taken at the same place by Capt. G. D. Franklin in 1912; concerning which the collector notes "the bites cause a great deal of discomfort, but no actual disease so far as I am aware."

This is probably a Western representative of *S. indicum*, Becher, which is common in the Eastern Himalayas and Assam; it differs from *S. indicum* chiefly in having less yellow at the base of the abdomen (*S. indicum* has the third segment yellow), more black on the hind femora, and a rather broader front. The two species are very distinct from most others known to me by the combination of flattened front tarsi and hairy radius, also by having the basal half of the front tibia yellow and the rest black.

ON THE INDO-MALAYAN SPECIES OF THE GENUS *MICROGASTER* (HYMENOPTERA, BRACONIDAE).

By D. S. Wilkinson,
Senior Assistant, Imperial Bureau of Entomology.

Key to the Species.

1. Smaller species, rarely exceeding 2·5 mm. in length, and never exceeding 3 mm. ... ... 2.
   Larger species, at least 4 mm. in length ... ... 5.
2. Antennae with no black markings ... ... 3.
   Antennae with at least flagellum black ... ... 4.
3. Length 2·5 mm.; 1st tergite black, strongly rugose and rugosely striate, and shining; areolet 4-sided ... ... *detractus*, Walk.
   Length 2·5—3·0 mm.; 1st tergite testaceous, slightly roughened and dull; areolet 3-sided ... ... *indicus*, sp.n.
4. Length 2 mm.; antennae wholly black ... ... *himalayensis*, Cam.
   Length 2 mm.; antennae with scape red testaceous and flagellum black ... ... *annulipes*, Mot., *nigricornis*, Mot.
5. Length nearly 5 mm.; antennae with 19 joints ... *carinicollis*, Cam.
   Antennae with the usual number of joints ... ... 6.
6. Length 4·5 mm.; areolet 3-sided; 1st tergite longer than broad ... *psarae*, sp.n.
   Areolet 4-sided; 1st tergite broader at apex than long down middle 7.
7. Length 5 mm.; 1st and 2nd tergites coarsely striate; hind coxae, hind trochanters and hind femora entirely deep black *kuchingensis*, sp.n.
   Length 4 mm.; 1st tergite punctate, 2nd almost entirely smooth; hind coxae black only at base, apically pale reddish testaceous; hind trochanters, hind trochantines, and hind femora pale reddish testaceous ... ... *tjibodas*, sp.n.

Microgaster detractus, Walk.

Microgaster detractus, Walker, Ann. Mag. Nat. Hist. (3) v, 1860, p. 308.

♂. Black; flagellum brownish red, hind legs from the femora to the claws blackish red; scape, fore and middle legs, hind trochanters and hind trochantines, light testaceous red; palpi almost white; basal ventrites whitish; stigma and wing veins brown.

♂. *Head* rugose throughout, except that the occiput is rugoso-reticulate and that the vertex between the ocelli and the toruli is rugoso-striate; face with indications of a median keel; antennae moderately thick and strong; basal joint of flagellum a little longer than twice its breadth, about 0·24 mm. long; clypeus apparently emarginate, just about half as long as distance between facial depressions, which latter are nearer to the eyes than to the apex of the clypeus; posterior ocelli nearer to the eyes than to each other. *Thorax*: mesonotum closely and strongly punctate, anteriorly almost rugose, as are also the mesopleurae except for a posterior median smooth and shining area; mesopleural sulcus apparently smooth; scutellum apparently rugose; metanotum apparently not crenulate; propodeon with an extremely short median longitudinal carina which, bifurcating at its apex, emits two strong carinae which, on each side, run transversely across the basal half of the propodeon and join a strong carina which in conjunction with a strong lateral longitudinal carina encircles the spiracles, as in *M. kuchingensis*; remainder of the

propodeon apparently rugose between broad reticulations, except outside the lateral keels, where it is only rugose. *Wings*: stigma about equal to or rather longer than the metacarp and with the radial from about the middle; in the forewings the 2nd abscissa of the radial present, in length somewhat less than the 2nd transverse cubital; the apical portion of the 1st abscissa of the cubital in one wing about equal to, and in the other wing less than, the 1st transverse cubital, which latter in both wings is noticeably shorter than the recurrent; the nervulus received into the 2nd abscissa of the medial distinctly before middle; wings apparently evenly infumate throughout. *Legs*: hind coxae less than half length of thorax, mostly rugose; the longer hind tibial spurs apparently about half length of basal joint of hind tarsus; the longer middle tibial spurs two-thirds length of basal joint of middle tarsus. *Abdomen*: 1st tergite strongly rugose, towards and at apex rugosely striate; 2nd tergite striate; 1st tergite about as broad at apex as long down the middle, which length is about one and a half times the basal breadth; the sides of the tergite in basal third are more or less parallel, they then diverge, the sides of the apical third being again more or less parallel, with no convergence at extreme apex; 1st suture well marked and more or less straight; 2nd tergite at base somewhat broader than the apex of 1st tergite, about as broad at base as apex, two and a half times as broad as long; 2nd suture apparently well marked and virtually straight; remaining tergites apparently smooth.

Length, 2·5 mm.

Ceylon.

Type in British Museum.

Redescribed from Walker's type, a specimen in none too good condition.

Microgaster indicus, sp.n.

♂♀. Testaceous; head, antennae, mesonotum, mesopleurae, and disc of scutellum, normally rather redder; lateral faces of the scutellum, metathorax, propodeon, 2nd and succeeding tergites, black; ocelli in a black spot; palpi white; stigma and wing veins brown.

The 3rd or 4th, and succeeding tergites are commonly reddish or even testaceous, while the legs are often as dark as the mesonotum. In one specimen the disc of the scutellum is black and the antennae are very dark.

♂♀. *Head* virtually impunctate and more or less smooth, except the face which is weakly punctate and has a weak, longitudinal keel in the upper half; the suturiform line joining the facial depressions is hardly apparent; antennae decidedly longer than the head, thorax, and abdomen together; flagellum with the majority of the joints about three times as long as broad; 1st flagellar joint about 0·24 mm. long; clypeus slightly emarginate; ocelli comparatively large, the distance between the posterior pair being about the breadth of one, the distance from the eyes being normally, but not always, rather less, the ocelli thus occupying the greater part of the vertex. *Thorax*: mesonotum and disc of scutellum rugulose and strongly setiferous; mesopleurae anteriorly and below rather indefinitely rugoso-punctate, discally smooth and shining; mesopleural sulcus shallow and broad; scutellar depression strongly crenulate; propodeon with a strong median longitudinal carina, along each side of which the propodeon is more or less indefinitely sculptured, otherwise, particularly at base, it is shining and more or less smooth; the propodeon is separated from the metanotum by a straight, deep, plain sulcus. *Wings*: stigma shorter than metacarp and with the radial emitted from beyond middle; the indistinct 2nd transverse cubital received into the 1st transverse cubital, the 2nd abscissa of the radial being absent, thus making the areolet triangular; the apical portion of the 1st abscissa of the cubital about equal to the recurrent, but shorter than the 1st transverse cubital; the 2nd abscissa of the medial not equally divided by the nervulus, the apical portion

being slightly longer ; the 1st transverse cubital not angled but evenly rounded and virtually a continuation of the line of the lower part of the 1st abscissa of the radial ; wings hyaline and nowhere infumate. *Legs* : hind coxae about two-thirds length of thorax, basally above more or less strongly punctate, below for at least apical two-thirds strongly rugulose and setiferous, elsewhere faintly rugulose or shining ; the longer hind tibial spur three-quarters and the shorter spur one-half length of basal joint of hind tarsus ; the longer middle tibial spur as long as the two basal joints together of the middle tarsus. *Abdomen* : 1st tergite somewhat broader at base than apex, the sides very slightly diverging and then converging to apex. 1·5 times as long as greatest breadth, which is beyond middle ; 1st tergite basally furrowed as in *M. psarae*, with the apex turned over and down, and the apical half rugulose and dull ; 2nd tergite rather less than twice as broad as long down the middle, medianly with a raised, virtually smooth or indefinitely sculptured area running the whole length of the tergite ; this area is twice as broad at base as at apex, basally occupying rather less than one-third of the breadth of the tergite, its sides straight, and down each side of it there runs a well marked, plain sulcus ; on reaching the apex of the tergite each sulcus is continued outwards to the lateral margins of, and along and marking the apex of, the tergite ; basally each sulcus becomes lost in a deep elongate impression which does not reach to the basal lateral margins of the tergite ; all tergites indefinitely sculptured ; ovipositor sheaths shorter than the shorter hind tibial spur.

Length, 2·5—3·0 mm.

India : Rahatgaon, Hoshangabad, Central Provinces, 12 ♀♀, 3 ♂♂, 20.ix.1926 (type), 18–19.viii.1926, 1–28.ix.1926, 5.x.1926, and 1.xi.1926 (*S. N. Chatterjee*).

Type deposited in the British Museum.

Host : bred from the larvae of the Pyralid, *Pyrausta machaeralis*, Walk.

Microgaster himalayensis, Cam.

Microgaster himalayensis, Cameron, Wien. Ent. Ztg. xxix, 1910, p. 5.

Described by Cameron from the female only. This species would seem to be remarkable chiefly on account of the 1st tergite, which bears on each side of its centre a distinct longitudinal keel, the two forming an area longer than wide.

I have not seen this species.

India : Darjiling.

Microgaster annulipes, Mot.

Microgaster annulipes, Motchulsky, Bull. Soc. Nat. Mosc. xxxvi, 1863, p. 34.

Described from the male only. I have seen neither this species nor the one immediately following ; it is quite possible that neither is referable to this genus (*vide* Cameron's introduction to his paper on the Ceylonese Hymenoptera, Spolia Zeylanica, iii, 1905, p. 69).

Ceylon.

Microgaster nigricornis, Mot.

Microgaster nigricornis, Motchulsky, Bull. Soc. Nat. Mosc. xxxvi, 1863, p. 35.

Ceylon.

Microgaster carinicollis, Cam.

Microgaster carinicollis, Cameron, Spol. Zeylan. iii, 1905, p. 81.

Would appear to be distinct on account of the number of joints in the antennae ; in fact the genus in which he has placed this species is queried by Cameron. I have not seen this species.

Ceylon.

Stated by Cameron to have been bred from the larva of a Lymantriid moth, *Dasychira securis*.

Microgaster psarae, sp. n.

♂♀. Shining black; the front coxae, middle femora, middle tibiae, hind trochanters, hind trochantines, hind femora, basal half of hind tibiae, mouth-parts except palpi, hind calcaria, scape, ovipositor, the greater portion of the tergites from the 3rd on, the ventrites, a shining and strong red testaceous; remainder of legs (except for apices of hind coxae on the outside which are black, and except for the apical half of the hind tibiae and the whole of the hind tarsi which are a dull reddish black, and except for a narrow dark annulus at base of hind tibiae, and for the claws which are dark), palpi, tegulae, 1st tergite, pronotum, and sometimes portions of the propleurae, a paler shining red testaceous to whitish stramineous; the scape invariably has a narrow dark red or black streak down the outside; the extreme apex of the clypeus is often tinged with red; flagellum dull black, often with indications of red on underside of basal joints; the abdomen often exhibits many indefinite streaks of black, and the 2nd tergite varies between distinctly reddish through red-black to blackish; in the forewings (fig. 1) the stigma, metacarp, costal veins, the 1st transverse cubital, and the 1st abscissa of the radial vein, brown, the basal vein, and the 1st and 2nd abscissae of the medial vein darker, the remaining veins paler.

♂♀. *Head* punctate more or less throughout, the punctation on the vertex being weak, that on the clypeus and face very strong and coarse, giving almost a rugose or reticulate appearance; face with a flattened, weakly raised, more or less smooth line or keel running down middle from between toruli to the well-marked suturiform

Fig. 1. *Microgaster psarae*, sp. n., forewing.

line joining the facial depressions; antennae thick and strong, about equal to length of head, thorax, and abdomen together; flagellum with no joint longer than twice its breadth; 1st flagellar joint about 0·3 mm. long; clypeus more or less truncate, about half as long as distance between facial depressions, which latter are noticeably nearer to the eyes than to the apex of the clypeus; posterior ocelli hardly further from the eye than from one another. *Thorax*: mesonotum anteriorly strongly punctate, the punctures, however, being definitely separated, posteriorly the punctures often becoming weaker and more widely spaced and sometimes entirely disappearing, although the strong punctation as often occurs posteriorly; mesopleurae anteriorly, posteriorly below, and posteriorly above narrowly, as strongly punctate as the mesonotum anteriorly; the broad posterior disc of the mesopleurae is devoid of punctures and is polished and shining, with a smooth sulcus; scutellum with a few strong punctures on its disc, and on its lateral faces strongly crenulate; scutellar

depression strongly crenulate; metanotum more or less crenulate throughout; propodeon with a strong median and strong lateral longitudinal keels, along the sides of which the propodeon is crenulate; otherwise the propodeon is entirely smooth, except possibly just outside the lateral keels, where there are sometimes a few punctures. *Wings*: stigma shorter than the metacarp and with the radial emitted from beyond middle; the forewings (fig. 1) with the hyaline but distinct 2nd transverse cubital vein received into the 1st transverse cubital, the 2nd abscissa of the radial being absent, thus making the areolet triangular; the apical portion of the 1st abscissa of the cubital vein just longer than both the recurrent and the 1st transverse cubital; the 2nd abscissa of the medial about equally divided by the nervulus; the 1st transverse cubital angled; about the apical half of both the radial and 3rd cubital cells, and about the apical third of the 2nd discoidal, and the apical third of the 2nd brachial, rather faintly infumated; the tips of the hind wings infumated. *Legs*: hind coxae more than half length of thorax, basally smooth, shining and virtually impunctate, apically below punctate and strongly pubescent; the longer hind tibial spurs rather more than half the length of basal joint of hind tarsus; the longer middle tibial spurs as long as or longer than basal joint of middle tarsus. *Abdomen*: 1st tergite (fig. 2) coarsely but rather sparsely punctate at and towards apex.

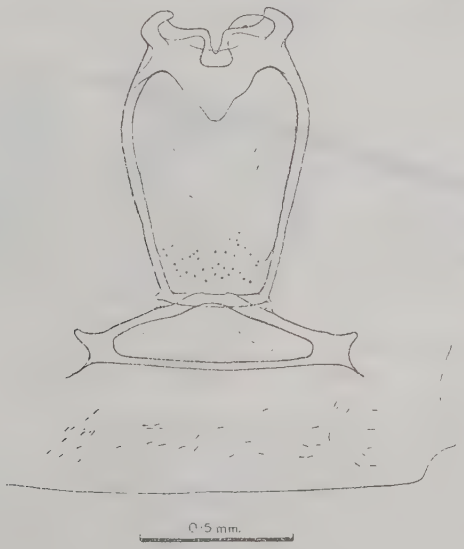

Fig. 2. *Microgaster psarae*, sp. n., 1st, 2nd and 3rd tergites.

and 2nd tergite virtually smooth, otherwise tergites smooth and shining; 1st tergite about one and three quarter times as long as broad basally, about one and a half times as long as extreme width, which is at about apex of basal third, and about two and a half times as long as broad at apex, for about basal two-thirds each lateral half somewhat and evenly raised, thus forming an even elongate rather flat v-shaped furrow, the apex of the tergite being turned over and down; 2nd tergite four and a half times as broad at apex as long down middle, basally very narrow, with its anterior margins oblique, making the lateral margins about one-third the median length, apical margin somewhat rounded; 3rd tergite about one and three quarter times as long as the 2nd; ovipositor sheaths about equal in length to hind coxae; ovipositor with a noticeable downward curve.

Length, 4·5 mm.; wing expansion about 10 mm.

Federated Malay States: Kuala Lumpur, 5♂♂, 12♀♀, v.1922, 12.xii.1924, 30.xii. 1924 (*G. H. Corbett*). India: Nilambur, Madras, 12♂♂, 8♀♀, 4–7.vii.1925 (*S. N. Chatterjee*).

Type deposited in the British Museum.

Host: the Malayan series was bred from the Pyralid, *Psara bipunctalis*, F., while the Indian series is recorded as bred from larvae of another Pyralid, *Pachyzancla aegrotalis*, Zell.

The pure white cocoons are separately constructed and are covered with strong white filaments.

Microgaster kuchingensis, sp. n.

♀. Black; scape mostly, front femora, and ovipositor, red testaceous; front tibiae with its spurs, and front tarsi, paler; middle and hind tibial spurs, basal quarter of hind tibiae, middle tarsi, stramineous; middle tibiae stramineous at extreme base and apex, blackish in the middle; in the forewings (fig. 3) the stigma, metacarp, costal veins, both transverse cubital veins, and the anal and the 1st and 2nd abscissae of both the medial and radial veins, dark brown, remaining veins paler.

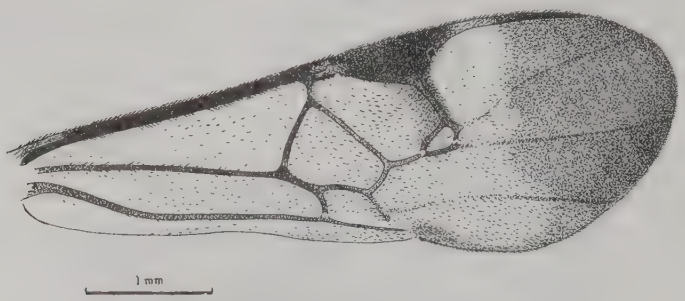

Fig. 3. *Microgaster kuchingensis*, sp. n., forewing.

♀. *Head* punctate more or less throughout, the punctures on the vertex being very weak, those on the face strong and coarse giving almost a rugose or reticulate appearance, those on the clypeus not quite so strong as those on the face; upper facial orbits markedly striate; face above with a fine median longitudinal keel running down from between the toruli and terminating before half-way down the face in a smallish shining elongately raised protuberance; the suturiform line between the facial depressions not well-marked; antennae thick and strong (apical joints broken); basal joints of flagellum just a little longer than twice their breadth; 1st flagellar joint about 0·36 mm. long; clypeus just a little less than half as long as distance between facial depressions, which latter are about equidistant from the eyes and the apex of the clypeus; posterior ocelli nearer to each other than to the eyes. *Thorax*: mesonotum strongly punctate, but not quite so strongly or so thickly as in *M. psarae*, and as in this latter species tending to have weaker punctures posteriorly; mesopleurae punctate as in *M. psarae*, and with a similar smooth shining area; mesopleural sulcus, scutellum, and scutellar depression, as in *M. psarae*; metanotum crenulate; propodeon with a strong median longitudinal carina which bifurcates rather beyond its middle, the area between the fork not being excavate; there are also on each side two strong lateral longitudinal carinae which form a fairly large, more or less semicircular arc completely enclosing the spiracle; below these

latter areas are other carinae forming fairly large and strong reticulations; from about the upper half of the median carina on each side there run laterally four or five somewhat weaker but still very well marked carinae which terminate in the inner carina of the area enclosing the spiracle—these carinae become more closely approximated the further they are from the median carina, so that, the one nearer the base of the propodeon being placed transversely, the apical one is strongly oblique. *Wings*: stigma shorter than the metacarp and with the radial emitted from beyond the middle; the forewings (fig. 3) with the 2nd abscissa of the radial present, in length about equalling or somewhat less than the length of the 2nd transverse cubital; the apical portion of the 1st abscissa of the cubital, the recurrent, and the 1st transverse cubital, all about equal, the former being possibly slightly the longest; the nervulus received distinctly before the middle of the 2nd abscissa of the medial; the 1st transverse cubital almost straight; about the apical half of the radial cell, the apical two-thirds of the 3rd cubital, rather less than the apical half of the 2nd discoidal, and apical third of and along lower margin of the 2nd brachial cell, and along both sides (particularly the inner side) of the 1st abscissa of the cubital vein, infumated, more strongly so than in *M. psarae*; the tips of the hind wings infumated. *Legs*: hind coxae more than half the length of thorax, more or less completely punctate; the longer hind tibial spurs at least two-thirds the length of basal joint of hind tarsus; the longer middle tibial spurs as long as or longer than basal joint of middle tarsus. *Abdomen*: 1st and 2nd tergites strongly rugosely striate, except that the 1st is entirely smooth on medial basal two-thirds and exhibits strong indications of smoothness on medial apical third, and except that the 2nd tergite has a medial triangular smooth area; 1st tergite at apex somewhat broader than its median length, but somewhat narrower than twice the basal breadth, about as broad as its lateral length, the sides being more or less straight; 1st suture strongly marked, deep, straight; 2nd tergite nearly as broad at base as at apex, the lateral margins only slightly oblique, nearly four times as broad at apex as its median length, apical margin straight; 3rd tergite one and one-third times as long as 2nd; ovipositor sheaths rather shorter than hind coxae, about equal to the middle femora; ovipositor with a noticeable downward curve.

Length, 5 mm.; wing expansion at least 11 mm.

BORNEO: Kuching, 2♀♀, 1 ?, undated (*J. Hewitt*).

Type in the British Museum.

The specimen that I have selected as the type for my species already bears a type abel and a label with the name "*Microgaster fortipes*, Cam." The other two each also bear type labels and labels in Cameron's handwriting with the words "*Microgaster malayanus*, Cam. Type. Borneo." I have been unable to find Cameron's descriptions for these specimens, and I am assuming, therefore, that these are merely manuscript names, as is almost undoubtedly the case. I should, however, have much liked to have found Cameron's descriptions and so to have discovered on what characters he presumed to separate these specimens into two species.

Microgaster tjibodas, sp. n.

♀. Black; palpi, tegulae, all legs (except as noted below), pale red testaceous; hind coxae black at base; hind tibiae at extreme apex and hind tarsi red brown; abdomen mostly dark testaceous red-black; stigma and wing veins brown.

♀. *Head*: face lightly rugose or with weak coalescent punctures, above with weak lateral striae; vertex impunctate; face with median longitudinal keel much as in *M. kuchingensis*; the suturiform line between the facial depressions not well-marked; antennae more slender, basal joints of flagellum at least three times as long as broad; 1st flagellar joint about 0·3 mm. long; clypeus punctate, decidedly emarginate, and about half as long as distance between the facial depressions, which

latter are equidistant from the eyes and the apex of the clypeus; posterior ocelli nearer to each other than to the eyes. *Thorax*: mesonotum anteriorly as strongly punctate as in *M. kuchingensis*, posteriorly smooth, shining and virtually impunctate; mesopleurae anteriorly with broad but shallow punctures, posteriorly smooth, shining and impunctate, with smooth sulcus; scutellum with some coarse punctures, weakly crenulate on its lateral faces; scutellar depression composed of five or six deeply impressed, contiguous, almost round punctures; metanotum crenulate; propodeon much as in *M. kuchingensis*, except that all the carinae are more weakly marked. *Wings* much as in *M. kuchingensis*, except that the imfumation, although equalling in extent that of the latter species, equals in degree that of *M. psarae*. *Legs* as in *M. kuchingensis*. *Abdomen*: 1st tergite coarsely but rather sparsely punctate, remaining tergites virtually impunctate; 1st tergite broader at apex than its median length, almost double as broad at apex as at base, the lateral margins in basal half more or less parallel, thence diverging outwards strongly, converging somewhat at extreme apex; 1st suture fairly well-marked; 2nd tergite one and one third-times as broad at apex as it is at base (or as the 1st tergite is at apex), double as broad at apex as its median length, with apical margin somewhat rounded; 3rd tergite as long as 2nd; ovipositor sheaths rather longer than hind coxae, about equal to middle tibiae; ovipositor with noticeable downward curve.

Length, 4 mm.; wing expansion at least 9 mm.

JAVA: Tjibodas, 5,000–7,000 ft., viii.1913 (*Dr. Koningsberger*). One female only.

Type in the British Museum.

Walker's three species, namely, *recusans*, *significans*, and *subducta*, that he described from Ceylon and assigned to the genus *Microgaster* (Ann. Mag. Nat. Hist. (3) v,1860, pp. 308–309), in reality belong to the genus *Apanteles*.

A species of *Microgaster* has been described from Formosa (*M. formosanus*, Matsumura, Mem. Soc. Ent. Belg. xviii,1911, p. 149). Since it has been suggested that, at least for the parasitic Hymenoptera, this island should be included in the Indo-Malayan region, mention is here made of this record. I have not seen this species, and it was found impossible to include it in the key, as it is quite unrecognisable from the description.

ON THE SPECIES OF GALL MITES (ERIOPHYIDAE) FOUND ON THE GENUS *RIBES*.

By A. M. Massee,
East Malling Research Station.

During recent years a great deal of research work has been carried out in connection with the control of the black currant gall mite *Eriophyes ribis* (Westw.) Nal. This work has necessarily included the very careful study of the mites themselves, in order that the life-cycle might be fully understood, with the final object of trying to exterminate the mites at a period when they offered least resistance and were not living within the buds, which afford them adequate protection.

While examining some black currant bushes in the late spring and summer months of 1923, in order to locate the position and determine the habits of the mites during that season, a rather peculiar form of mite was noticed to be present in small numbers. This new mite, when examined in the field, appeared to be very much stouter and of a darker colour than the familiar black currant gall mite. However, for some time it was regarded as being an immature stage of the common species. After some months this mite turned up again in greater numbers, and it was decided to examine it in detail in the Laboratory. The species proved to be a new one belonging to the genus *Phyllocoptes*.

Specimens were forwarded to Dr. Alfred Nalepa, the famous Viennese Zoologist, who described the species in detail and named it *Phyllocoptes masseei*, Nal.

Mites in all stages are found on the lower surfaces of leaves of the black currant during the latter part of July and in August. They may be detected on the foliage earlier in the season, but are very difficult to find owing to their small numbers. Eggs can be observed on the leaves, but these, again, are difficult to see on account of their small size. Towards the end of August and in September very few mites remain on the leaves, since at this period the majority seek shelter under the bud scales for the winter. They do not congregate in little groups, as is common with many species, e.g., *E. gracilis*, Nal., but are invariably found singly under the scales. In the early spring, exactly at what period is not clear, they migrate to the leaves and continue their life-cycle on the open bush.

So far it has not been found in company with the black currant gall mite, although it is sometimes present on the same bush.

In all probability this species is much more plentiful than is generally supposed, and this is doubtless due to the fact that it is very difficult to detect on a bush, since it does not damage or malform the leaves to any marked extent. Only in very severe cases of attack slight mottlings are noticeable on the upper surfaces of the leaves.

The third species of gall mite found on black currant belongs to the subfamily Phyllocoptinae and is included in the genus *Oxypleurites*. This genus is a very small one, containing but 10 species, none of which has been recorded previously in this country.

It is of interest to note that this species was found by the writer as far back as 1921, but it was not collected in sufficient numbers to allow a detailed description to be made of it. It is here described under the name of *Oxypleurites neglectus*, sp.n.

It is found amongst the hairs on the lower surfaces of leaves of black currants during the summer months, and it is usually associated with *Phyllocoptes masseei*, Nal.

In passing it may be recorded that another species of *Oxypleurites* has been found in this country feeding on the lower surfaces of hazel leaves. This species, *Oxypleurites depressus*, Nal., was recorded by Nalepa as long ago as 1894, from material collected in Central Europe.

The three species are fully described below, together with references, host-plants, etc.

Finally, a key is appended to enable students to separate the species into their respective genera.

Eriophyes ribis (Westw.) Nal.

1869. *Phytoptus ribis*, Westwood, Gardener's Chronicle, p. 841.

1893. *Phytoptus ribis*, Nalepa, Anz. Ak. Wien, xxx, p. 105.

1898. *Eriophyes ribis*, Nalepa, Das Tierreich : Erioph., p. 24.

Body much drawn out, cylindrical. Shield 34μ long, triangular, anterior edge projecting forwards and partly covering rostrum, lateral edges very slightly projecting. Thoracic shield marked with 5 longitudinal furrows which are drawn through central portion of shield. Sides of shield strongly punctate and marked with indistinct longitudinal curved lines. Thoracic bristles absent.

Rostrum short, 16μ long, stout, sloping towards apex. Chelicera 20μ long. First pair of legs 36μ long, 4th and 5th joints almost equal in length, 16μ long ; tarsal bristles 18μ, femoral bristles 24μ, claws 8μ long. Second pair of legs 33μ ; 4th and 5th joints 14μ ; bristles strong ; feathered claws 5-rayed, 6μ long, delicate ; claws 10μ long.

Sternal ledge deeply forked. First pair of coxal bristles situated behind anterior edge of sternal ledge, short ; 2nd pair placed before the inner coxal angle ; and the 3rd 40μ long, moderately stout.

Abdomen marked with punctate rings on dorsal and ventral surfaces, there being 70 rings. Lateral bristles 30μ long, placed in line with genital organ. First pair of ventral bristles 45μ long, 2nd pair 9μ, 3rd pair 15μ, fine, hairlike. Anal lobe moderately small, conspicuous. Caudal bristles prominent, long, tapering hair-like towards apex. Accessory bristles absent. Epigynium raised, basin-like, 21μ broad. Coverflap marked with longitudinal lines. Genital bristles situated at lateral edges, short.

♀, 220μ long, 40μ broad ; ♂, 150μ long, 38μ broad.

Host-plants : *Ribes nigrum*, L., *R. rubrum*, L., *R. alpinum*, L., *R. grossularia*, L., *R. sanguineum*, Pursh. Malformation of buds, the so-called " big-buds."

Distribution : British Isles ; Central Europe ; British Columbia. Abundant and generally distributed.

Phyllocoptes masseei, Nalepa.

1924. *Phyllocoptes masseei*, Nalepa, Marcellia, xxi, p. 95.

Body spindle-shaped. Shield 47μ long, triangular, anterior edge projecting forwards and partly covering rostrum, lateral edges slightly projecting. Thoracic shield marked with longitudinal furrows, which are often broken up, three of them passing through central portion of the shield. Two other longitudinal furrows are present, one being situated on each side, and closely bordering median furrows. Warts of thoracic bristles large, widely separated, and situated near the lateral edges. Thoracic bristles 30μ long, stout, acuminate.

Rostrum short, 30μ long, stout, sloping towards apex. Legs fairly stout ; 1st pair 38μ long, 4th and 5th joints 21μ, tibial bristles 7·5μ, femoral bristles 1·3μ.

Second pair of legs 34μ long, 4th and 5th joints 17μ, bristles weak, feathered claw 4-rayed, delicate. Claws of second pair of legs 9·5μ long, claws of first pair a little shorter.

Sternal ledge simple, short. First pair of coxal bristles situated behind the anterior end of sternal ledge, second pair before the inner coxal angle, and the third pair 38μ long and slender.

Abdomen with smooth, narrow tergites, the number of which varies, there being generally 41, less frequently 34. The ventrites very narrow, very fine, and closely punctate. Lateral bristles 28μ long, fine, situated high up on the 4th tergite; 1st pair of ventral bristles 50μ long, 2nd pair 25μ, 3rd pair 31μ, tapering hair-like towards apex. Anal lobe small. Caudal bristles short; accessory bristles very slender and short. Epigynium flat, 34μ broad. Coverflap marked with indistinct fine lines. Genital bristles placed near lateral edges, 26μ long.

♀, 170μ long, 40μ broad; ♂ unknown.

Host-plant: *Ribes nigrum*, L. Free-living on lower surface of leaves.

Distribution: Sevenoaks and East Malling, Kent, England. Not common.

Oxypleurites neglectus, sp. n.

Body stout, spindle-shaped. Shield semicircular, large; anterior margin projecting forwards, covering rostrum. Lateral margins slightly projecting. Posterior margin partly covering first tergite. Shield angles tooth-like, weak. Thoracic shield ornamented with three indistinct longitudinal furrows, which pass through median portion of shield; the furrows irregular and often not continuous; a few indistinct curved lines near the lateral edges of the shield, and the remaining surface smooth. Warts of thoracic bristles very large, widely separated and situated near the lateral margins. Thoracic bristles 18μ long, very stout, acuminate, projecting backwards.

Rostrum short, 30μ long, slender, curved downwards. Legs moderately stout. First pair 39μ long, 4th and 5th joints 15μ; 2nd pair 36μ long, 4th and 5th joints 12μ; leg bristles weak, not conspicuous; feathered claw 4-rayed, delicate; claws of 1st and 2nd pairs of legs 8μ long.

Sternal ledge simple, of medium length. First pair of coxal bristles situated in line with inner coxal angle, 2nd pair in line with the anterior end of sternal ledge. Abdomen with 17 smooth, broad tergites, of which the first 14 are regular and equidistant, the last 3 being situated immediately before anal lobe and markedly narrower, margins of tergites (except the last three) regular, tooth-like. Ventrites more numerous than tergites, very narrow, and closely punctate. Lateral bristles 12μ long, in line with anterior edge of epigynium; 1st pair of ventral bristles 24μ, acuminate; 2nd pair 15μ; 3rd pair 19·5μ, tapering hair-like at apex. Anal lobe small, keel-like. Caudal bristles moderately short; accessory bristles absent. Epigynium basin-shaped, 24μ broad. Coverflap smooth, slightly arched. Genital bristles situated near lateral margins, 13·5μ long. Epiandrium 15μ broad, smooth, strongly arched.

♀, 180μ long, 48μ broad; ♂, 140μ long, 45μ broad.

Host-plant: *Ribes nigrum*, L. Free-living on the lower surfaces of leaves. Usually found in association with *Phyllocoptes masseei*, Nal.

Distribution: East Malling, Kent, England. Rare.

Key to Genera of Mites described above.

a. Abdomen without dorsal longitudinal furrow, narrowly ringed, punctate; three pairs of ventral bristles ... *Eriophyes* (Sieb.) Nal.
b. Abdomen not equally ringed; 17 tergites; ventrites numerous, obviously narrower than tergites ... ... *Phyllocoptes*, Nal.
c. Tergites projecting tooth-like at sides ... ... *Oxypleurites*, Nal.

ON A LYCAENID BUTTERFLY ATTACKING PINEAPPLES IN TRINIDAD, B.W.I.

By W. Victor Harris, B.Sc.

(Plates VII–VIII.)

The pineapple is a plant indigenous to Central America and, it is believed, Trinidad also. In this part of the world its cultivation has developed on commercial lines only in Cuba and Porto Rico, and to a lesser extent in Jamaica, with small areas in other islands, particularly Martinique.

There have been of late indications of an increased interest in the possibilities of fruit production on a large scale in Trinidad, the pineapple being among the favoured fruits. For this reason the pest dealt with below assumes a greater importance than it otherwise would, though the usual freedom of this plant from pests focuses attention on any new one found.

In October 1926, young fruit on the plots of the St. Augustine Experiment Station of the local Department of Agriculture were found to be exuding gum and showing signs of insect attack. Though at the time there was few fruits, it being too early for the main crop, a high proportion of these was found to be damaged. It was reported that many fruits had been rendered unsaleable during the previous season by a similar attack.

The Cause and Nature of the Damage.

Dissection of affected fruit yielded a pink Lycaenid larva present in the early stages of the damage. Writing in 1922, Mr. Urich[1] says "wild growing pines have been observed to be attacked by the caterpillar of a Lycaenid butterfly, which burrows into the young fruit and completely ruins it." This is no doubt the same insect, as wild pines were later found to be similarly attacked.

Imagos were reared and forwarded for identification to the Imperial Bureau of Entomology, and to the United States Bureau of Entomology, to whom we are indebted for their assistance. It is given by the Imperial Bureau as *Tmolus echion*, L. The Washington Bureau refer it to the synonym *Thecla basilides*, Geyer, adding that it is "injurious to pineapples throughout tropical America," and "occurs from Mexico to Argentine." It is recorded by Kaye[2] as *Tmolus echion*, L., in his list of Trinidad Lepidoptera.

The injury to the fruit is indicated superficially by the exudation of gummy matter from the points of attack. At first practically colourless and quite fluid, the gum hardens in contact with the air, going through pale amber to a final dark brown colour when quite hard. Removal of the gum shows either an irregular shallow depression, or, more usually, a small circular hole leading into the interior. Inside the fruit, the larva usually makes a small cavity before proceeding towards the surface again. These burrows do not extend inwards for more than one-third of the diameter of the fruit, unless the larvae are confined with an inadequate food supply. As the fruit develops these holes fill up with gum, which preserves a stiff jelly-like consistency while turning a deep brown colour. The edges of the wound blacken. Such places frequently become secondarily infected with a green fungus, with eelworms, Collembola, millepedes, small Dipterous larvae, and minute brown beetles, all of which further disintegrate the fruit. Soft rot has been noticed, apparently spreading from *Tmolus* injury. The shallow depressions occasionally harbour "white scale."

Gum is only exuded from the deeper holes, the shallow excavations apparently drying out rapidly. Some time elapses before the gum appears on the exterior; in one case of a half-grown Chocana variety it appeared 47 hours after the larvae had

commenced to burrow. Thus there is ample time for the larvae to have left for another part of the fruit. Attempts were made without success to produce gum secretion by mechanical injury to growing fruit. Deep cuts with a knife, scraped at intervals for several days, had no effect and healed up, leaving only a scar. Scale-insect attack does not produce any gum, so that it would appear to be a specific reaction to *Tmolus* larvae. Microscopic examination of the edges of the wounds indicates that the gum is produced by a general breaking down of the parenchymatous tissue bordering the injury, progressive in nature, thus differing from a wound gum reaction to mechanical injury as exhibited by some plants.

A pineapple is rendered unfit for sale by the presence internally and externally of this brown gum, also by the distortion frequently occurring as a result of the injury (Pl. viii). Even slight attacks render the fruit useless for export, and a dead loss where there is no canning industry on the spot.

Somewhat similar damage has been recorded from Grenada on pines attacked by the weevil *Cholus wattsi*, Marshall. It is stated that " the feeding punctures of the adult completely spoil the fruit. A badly attacked pine will show gummy exudations, and will be deformed and undersized."[3] In this case, however, most damage is done by larvae feeding on the fruit-stalk, and in the centre of the developing fruit, two points which readily separate it from *Tmolus* injury.

Description of the Stages of Tmolus echion.

The Imago (Pl. vii, figs. 1, 2).—It is small in size, averaging 28 mm. across the expanded wings. The upper surface of the wings is of a slate-grey colour, bordered by a narrow, dark band, and a fringe of white scales. The hind wings have two orange eye-spots on the cubital border between the veins Cu_1 and Cu_2, and between 2nd A and 3rd A, each with an additional white band inside the darker rim, and a deeper coloured centre spot. There is a pair of delicate tails tipped with white on each hind wing, apparently prolongations of Cu_1 and Cu_2. The lower surface is pale grey, with rows of white-edged orange spots. The eyes are black, fringed with a conspicuous rim of white scales. The antennae are ringed with white. The legs are alternately banded with black and white scales. The males are generally smaller in size than the females, and bear in the middle of the costal region of the forewings a large dull black spot, the discal stigma, which is filled with androconia, or scent scales. While the forelegs of the female are normal and bear paired claws, those of the males are shorter, owing to fusion of the tarsal segments, non-functional, and bear a single claw.

The Egg.—The egg is circular, 0·8 mm. in diameter, flattened from above. It is a glossy white, with a finely reticulated surface. There is a central micropyle, depressed, smooth, and apparently darker in colour owing to thinness of the shell.

The Larva.—On hatching, the larva is 1·5 mm. in length. It is pale in colour, with the abdomen almost transparent, the head and thorax being rather darker ; the eyes show as two dark spots, and the mandibles are pale brown. During the first instar it bears little resemblance to its later forms. The head is held forward, uncovered, as is general among Lepidoptera ; the abdomen bears four rows of long hairs, up to 0·5 mm. long, and four rows of shorter ones. The end of the abdomen is flattened as in the later stages.

The second and subsequent instars are similar in appearance to one another, merely increasing in size, and exhibiting the typical onisciform, or woodlouse-like form of Lycaenid larvae in general.

The fully grown larva (Pl. vii, fig. 3) varies in length, but is generally 18–20 mm., with a width of 6 mm. It is compressed dorso-ventrally, the head is retracted beneath the large shield-like prothoracic segment, and the three terminal segments of the abdomen are more or less fused together and flattened to a wedge-like form. It is yellow in colour with longitudinal pink or deep red markings. The general effect

depends on the strength of these markings, which consist of a median pair along the dorsal vessel, another pair on each side of this, and a third pair running laterally below the spiracles, five pairs in all. In the paler forms the lowest pairs do not occur.

There are eight pairs of abdominal spiracles. Prolegs are borne on segments 6-9 and on the terminal one. The skin is shiny, with a thin covering of short yellow hairs, particularly at the sides. There is a transverse median slit on the posterior dorsal border of the 10th segment, which is the opening of the dorsal gland. It is surrounded by a ring of fine bristles.

The Pupa (Pl. vii, fig. 4).—The size of the pupa depends to a great extent on the development of the larva, and when fully developed is about 13 mm. in length. It is pink with dark markings. The second and third segments together form a characteristic dorsal hump on the thoracic region.

Attachment is secured by threads from the cremaster and a thin silk girdle round the middle.

Life-history and Habits.

The adult butterflies may be seen flying over the pine apple beds at all hours of the day. Their flight is rapid and usually of short duration, as they pass from flower to flower. The females seek out those pine flowers in a very early stage of development for the purpose of oviposition. The majority of eggs have been found on the small flowering heads while still down among the leaves, and few have been observed on heads after the first three rows of flowers have opened. The first symptoms of attack are thus found on the lower part of the fruit. The female alights on a flower or scale and, keeping up a continual rubbing together of the hind wings, moves about till a suitable place is reached. Then the abdomen is bent down almost at right angles, and the egg deposited. The eggs are laid singly, widely separated. The maximum number found on any single head was sixteen, with no indication that this was the work of one insect. The eggs are usually attached to the base of a scale; others are found on the buds, and some have been observed on the stem just below the head (Pl. viii).

Attempts were made throughout the period October to March to obtain eggs from females in captivity, but without success. Females were collected in the field and placed in cylinders with young pines, without results. Others were placed in a large insect house with pines of various ages kept fresh in water, with no better effect. At various times numbers of reared imagos, up to 25, were liberated in the insect house, and though there were present both males and females of a similar age, neither copulation nor oviposition was ever observed.

Dissection of a newly emerged female showed eight ovarian tubes, in two batches of four. The most complete tube contained 18 distinguishable eggs in various stages of development; thus giving the potential possibilities of the female as approximately 150. At 24 hours, two insects yielded 17 and 13 developed eggs in the oviducts, none having been laid previously. There was a marked discontinuity of development of the eggs after the numbers named. This suggests that the presence of so many developed eggs inhibits further development or else that the actual egg-laying capacity of the female is only a fraction of the earlier potentialities.

The eggs hatch in from 3 to 5 days. Those found to have been deposited on foreign matter, such as dead leaves inside the rosette, were never observed to hatch. The larva can be seen coiled inside the egg just prior to hatching with head applied to the micropyle, which it bursts and enlarges regularly with the mandibles until a circular hole of sufficient size is made.

The larva immediately seeks out a suitable place for entering the young pine. It is very active at this stage. A usual point of attack is the tender fleshy base

of a scale where it is attached to the main body. Opening flowers are eaten into direct through the petals to the ovary. Unopened buds are entered at all points. That part of the stem immediately below the head and between the suckers is occasionally superficially eaten. The initial burrows are usually shallow and confined to the lower parts of the fruit. Then the rapidly growing larva seeks a further entrance, this time with apparently less regard for the tenderness of the epidermis. Also by this time the fruit is further developed and flowering has finished, giving the larva more scope. This time a cavity is made below the surface and the larva is less exposed to attack from predators. After a period of 13 to 16 days, the larva reappears, ceases feeding and actively descends the fruit stalk to the leaves which cluster about its base. Hidden away in this constricted space it becomes quiescent, and pupates within 24 hours. Pupae have also been found among large basal suckers, but not in any great number.

The pupal stage occupies from 7 to 11 days. An attempt was made to influence this time by keeping the pupae under different conditions of atmospheric humidity. Three large desiccators were obtained charged with sulphuric acid at concentrations of 56·2, 43·7, and 18·7 per cent., corresponding at 30° C. with humidities of 25, 50 and 90 per cent., respectively. Into these vessels were placed numbers of newly formed pupae, but no significant variation was noted. Thus the time of pupation is not influenced by atmospheric humidity between 25 and 90 per cent.

The complete life-cycle thus occupies a period of 23 to 32 days, with an average of 28 for those under observation.

Wheeler[4] refers to the relations of Lycaenid larvae with ants, stating that no less than 65 species, representing 29 genera, are attended by ants. He says "as Guenée long ago (1867) showed for *Lycaena baetica*, these caterpillars possess three peculiar organs, one an unpaired gland in the mid-dorsal line of the ante penultimate or eleventh segment, and a pair of short protrusible tentacles on the dorsolateral portions of the penultimate, or twelfth segment. The median gland has the form of a sac or papilla which can be protruded through a transverse, mouth-shaped slit, and each of the tentacles is fringed at its tip with a dense circlet of stiff, finely plumose hairs. The ants caress the posterior, somewhat flattened extremity of the caterpillar with their antennae, as they do that of the plant louse, and the caterpillar responds by emitting from the median gland a glistening droplet of a colourless and presumably saccharine liquid which is eagerly imbibed by the attendants. The function of the tentacles is unknown." The median gland is present in *Tmolus echion*, but apparently on the tenth segment, as stated before. The tentacles have not been observed. The presence of larvae in a pineapple has been noticed to increase greatly the number of ants visiting the fruit. Ants have been observed paying great attention to larvae at or near the surface, but no secretion of fluid by the larvae has been seen in consequence.

Alternative Host-plants.

In Trinidad *Tmolus echion* has been reared from wild pines from various localities in the bush at the foot of the Northern Range. These wild pines occur frequently in large patches in the bush all over the hills; they are small, tender, and exude much gum as a result of the attack.

Another host is the closely related genus *Aechmea*, of the same order Bromeliaceae. This genus includes a number of common epiphytes, widely distributed over the island. The bright pink colour of their flowering shoots forms rather a feature of the vegetation during the early months of the year. Eggs and larvae have been found commonly on the flowering stems, and imagos have been reared from numerous localities in the northern part of the island. As there is no discontinuity in the

distribution of this genus, there is nothing to suggest that *Tmolus echion* will not occur on it all over the island. The fruits are eaten into, and a slight exudation of milky white gum results.

A third host is provided by at least one species of *Heliconia* common in the bush and rough ground generally in the northern area.

The life-cycle is uninfluenced by the different food-plants, and interchange of larvae has resulted in no apparent deleterious effect on the larvae. Thus the presence of these plants on the trees of an estate or in surrounding bush will act as foci of infestation for any pineapple beds laid down.

Parasites and Predators.

During this investigation no parasites have been reared from the eggs of *Tmolus echion* in spite of large numbers from different localities being kept under observation. One well developed fruit found in the bush on top of the Northern Range above Arima bore a number of empty egg-shells which had been opened with less care than is usual for the larva, and suggested instead the emergence of parasites. Mr. Urich tells me that some years ago he obtained parasites from the eggs on wild pines but that the record of these has been lost.

A larval parasite has been bred out on two occasions, once from a cultivated pine, and again from a wild pine. It has been identified at the Imperial Bureau of Entomology as *Heptasmicra* sp. (close to *H. trinidadensis*). It is a typical Chalcid of the subfamily CHALCIDINAE, about 5 mm. in length, pale yellow with black markings on head, thorax and hind end of abdomen. The hind femora are generally swollen, and dentate on the lower surface where the tibiae are held in close approximation. The first of these emerged on 27th November 1926, after the host larvae had pupated apparently normally on 19th November 1926. This parasite is apparently of too infrequent occurrence to be reckoned as a controlling factor during the season under review.

One predator has been observed at work. This is *Polistes rubiginosus*, a Vespid wasp, known locally as the Jack Spaniard. They are usually present in numbers when the pines are flowering, together with numerous other wasps and bees. On one occasion a Jack Spaniard was observed for some time extracting a small larva from a shallow hole on the stem of a pine. The larva was completely withdrawn, when the wasp was unfortunately disturbed and flew away without its prey. The larva, on examination, was found to have been killed by the wasp. This indicates the possibility of *Polistes rubiginosus*, whose predatory activities are well known, exercising a definite control over *Tmolus* where it is present in sufficient numbers. In this connection it was noted that the attack on the pines at the St. Augustine Experiment Station was more severe than that on the College plots, whereas *Polistes* was much commoner on the latter.

Cannibalistic tendencies showed themselves on several occasions among larvae in captivity, particularly when in an early stage of development. This may have been merely a result of confinement, but was never occasioned by any shortage of food. It occurred in one instance when there were only two larvae, five days old, in a vessel 55 mm. in diameter.

Control Measures.

Observations have led to the conclusion that different varieties of pines vary in their susceptibility to attacks of *Tmolus echion*. "Sugar Loaf" and "Black Antigua" suffered much damage and exuded gum freely. They are thin-skinned fruit of local origin, easily bruised and unsuited to the export trade; also they are damaged by birds and mongooses. Two varieties imported from Porto Rico, "Red Spanish" and "Chocona," are thicker-skinned and suffered much less; they gave

less gum when attacked than the other two varieties. Other factors, such as flavour and suitable shape, will have to be taken into consideration, but " Red Spanish " appears to fulfil these conditions too, and would seem to be the pine best suited, so far, to Trinidad conditions.

A number of plots at the St. Augustine Experiment Station were sprayed with Bordeaux mixture, 5.5.50, in February when the majority of the flowering heads were just appearing. The plots were sprayed once only, and unsprayed controls were left on each bed. As the fruit developed, the value of spraying became evident to a degree more than justifying its cost. The following results were obtained for the first picking. Though they represent fruit which would have commenced development before the time of spraying, they are indicative of its value. Had later figures been obtainable they would undoubtedly have shown up much more favourably.

Date of spraying ... 15th February 1927.
Date of first picking ... 30th May 1927.

i. " Red Spanish "—
Sprayed (5 plots of 50 plants), 24 good, 18 gummed.
Unsprayed (7 plots of 50 plants), 20 good, 25 gummed.

ii. " Black Antigua "—
Sprayed (2 plots of 100 plants), 10 good, 12 gummed, 13 damaged.
Unsprayed (2 plots of 100 plants), 4 good, 11 gummed, 7 damaged.

iii. " Sugar Loaf "—
Sprayed (2 plots of 100 plants), 4 good, 12 gummed, 14 damaged.
Unsprayed (2 plots of 100 plants), 3 good, 15 gummed, 6 damaged.

" Damaged pines " refers to fruit rendered worthless by birds and mongoose, and includes both gummed and clean fruit.

The necessity for early spraying must be emphasised, so that the pest be caught in the egg or young larval stage. Developed larvae are apparently unaffected by spraying, probably owing to their rarely feeding on the surface.

It is recommended that pines which show signs of heavy infestation in the early stages be removed and burnt. Such fruit will, if left, never prove of any value, and their destruction will remove many larvae. The practice of leaving the suckers lying in heaps about the beds after picking should be discouraged as they may harbour pupae. Where attack is at all likely, the value of growing the pines in not more than three rows to a bed will be found in the increased facilities for detection and control measures.

This study was carried out at the Imperial College of Tropical Agriculture, Trinidad, B.W.I., under the direction of Professor H. A. Ballou, to whom I am indebted for his advice and helpful criticism. I have to thank Professors Hardy and Cheesman for their help, and Mr. Brunton, Manager of the St. Augustine Experiment Station, for permission to observe the plots there, and use the results of his spraying experiment.

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Fig. 1. *Tmolus echion*, L., ♀. × 2·5.

Fig. 2. *Tmolus echion*, L., ♀, underside.

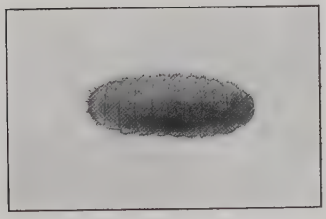
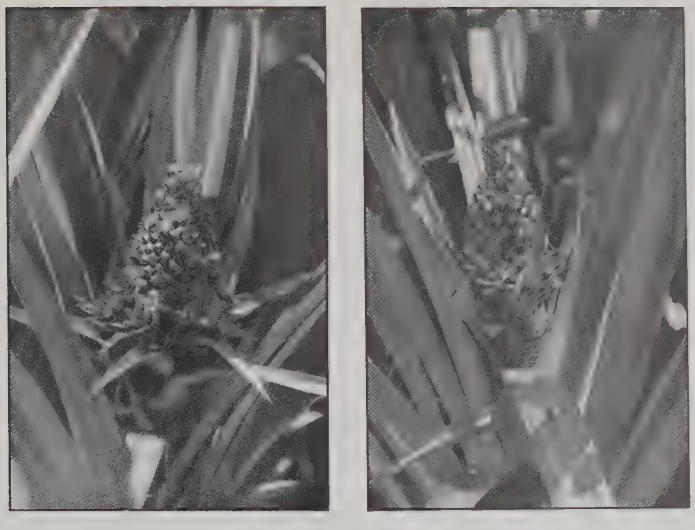


Fig. 3. Full-grown larva of *Tmolus echion*.

Fig. 4. Pupa of *Tmolus echion*.



"Sugar-loaf" and "Black Antigua" pineapples attacked by *Tmolus echion*, L.

Young pineapple showing eggs of *Tmolus echion*.

ON THE HEDYCRYPTINE GENUS *ONEILELLA*, CAM. (HYM., ICHNEUMONIDAE).

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[In 1919 work on the genus *Oneilella* was begun by the author and Mr. R. E. Turner. General agreement was reached as to the species represented in the material studied, and a table constructed before Mr. Turner's return to S. Africa. Subsequently all the additional material now dealt with was seen by Mr. Turner, and determined in collaboration.]

The genus *Oneilella*, Cam. 1904, created for the reception of *Cryptus formosus*, Brullé 1846, has up to the present remained monotypic. That it contained many more species was evident after an examination of the examples of this genus available in the British Museum collection and in various collections forwarded for identification to the Museum or received through the Imperial Bureau of Entomology. The material so gathered together (over 450 specimens) is, with one doubtful exception, African in source and dates from 1848 onwards. Its analysis has been a matter of some difficulty and has been undertaken chiefly because of the economic importance of some of the species. In the following pages an attempt has been made to summarise our present knowledge of the genus and its parasitism, and to describe such forms as appeared to be new.

At a meeting of the Entomological Society of London (2), in June 1878, several cocoon-masses of an *Anaphe* allied to *A. panda*, Boisd., were exhibited. Some of these were noted to be parasitized at the time, and from them were subsequently bred several Ichneumonids determined by F. Smith as *Cryptus formosus*, Brullé. Smith adds (l.c.) that this species also attacks *A. reticulata*, Wlk. As regards the first record, we cannot now find in the British Museum any *Oneilella* with the date and locality (Kamerun) in question. Further, so far as one can at present judge, the range of true *formosus* is more southern. There is, however, in the collection a ♀, without data, correctly determined as this species, to which Smith's remarks may refer. The second record rests on an example still extant. It is noticed here under *O. caudata*.

Cameron (4) states that *formosus* in the Cameroons attacks *Anaphe reticulata*, Wlk. —probably an imperfect recollection of Smith's remarks. *O. latifascia* and *O. analis* have also been bred from *Anaphe* spp. The following note summarises our knowledge of this parasitism.

Host				Parasite		
Anaphe	*moloneyi*	...	...	*Oneilella*	*analis*	
,,	*venata*	...	...	... ,,	*nigeriensis*	
,,	,,	...	...	... ,,	*latifascia*	
,,	*reticulata*	...	...	... ,,	*caudata*	
,,	,,	...	...	... ,,	"*formosa*"	
,,	*panda*	...	...	... ,,	*latifascia*	
,,	*infracta*	...	...	...	,,	
,,	*ambrizia*	...	...	... ,,	*linearis*	

On Damba Island, Lake Victoria, Carpenter observed *O. arcolata* flying in numbers round a tree-trunk. His captures were all males and it is probable they were swarming round one or more virgin females. Father J. A. O'Neil, after whom the genus is named, took a male of the genotype on fennel near Grahamstown. Neave's careful notes of altitude range from 2,000 ft. upwards. White took *O. latifascia* between 6,000 and 7,000 ft. in Nyasaland, while the highest point reached by a member of the genus is 10,000 ft., on Mt. Ruwenzori (*O. contracta*).

Members of the genus occur from the Cape to Senegal, Sudan (Darfur), Uganda and Abyssinia, *i.e.* throughout the whole Ethiopian region. We have also had before us a ♀ specimen with the data "*Ateleonotus ruficeps*, Cam. Type, Mendoza" which agrees with Cameron's description of that species (6) and is presumably the genotype. This specimen is in our opinion a true *Oneilella* belonging to the *subquadrata* section. For the present the genus *Ateleonotus* has been sunk as a synonym, though it may have to be reinstated should the group to which it applies prove sufficiently distinct for generic recognition. This seems to us unlikely and we have further doubts as to the locality given by Cameron for this species. It would be strange if a genus only otherwise known from and dominant in Africa should occur typically in South America.

A second specimen in the British Museum calls for remark. It is labelled "*Cryptaulax ruficeps*, Cam., type. ♂. Natal." This is plainly not a *Cryptaulax* according to the description of that genus (5) but an *Oneilella* of the *subquadrata* section. At first we suspected some interchange of labels, but on further consideration are inclined to believe that the example under discussion must be the subject of Cameron's remarks (5, p. 152). "The ♂ I have described may belong to another species as e.g., the forewings are not hyaline at the base, and the hinder parts are entirely smoky. The material at my command does not warrant me in describing the ♂ as a distinct species." *Cryptaulax*, Cam., applies to a group of Hedycryptines with two-spotted or banded wings and a non-areolated propodeon which descends gradually to the petiole. There are additional points of distinction and the genus is apparently valid. The type of the genotype is a ♀ and for this reason no confusion can arise from Cameron's mistake with regard to the ♂. The specimen is in bad condition and we have not dealt further with it.

Subfamily HEDYCRYPTINAE.

It has been shown (7, 8) that *Cryptus*, Jur. 1801, a Tenthredinid genus, renders invalid *Cryptus*, Fab. 1804, as a homonym.

Bradley (8) expresses the opinion that as *Hedycryptus*, Cam. 1903, is the oldest available synonym of *Cryptus*, Fab. sens. str. (so far as descriptions enable one to judge), Cameron's name, with a corresponding alteration of the subfamily designation, should now be employed, provided that an examination of Cameron's type discovers nothing discordant with the sense in which *Cryptus*, Fab., has hitherto been understood. This examination we have made and find that *Hedycryptus*, Cam., is a true synonym of *Cryptus*, Fab. For the present therefore *Hedycryptus* and its derivative must be employed for the genus and subfamily, but bearing in mind the somewhat artificial divisions which have been made in this family, it seems probable that the tendency in the future will be to slump rather than to split, in which case some older name may have to be restored.

The comparatively large areolet would seem to negative any proposal to place *Oneilella* in the MESOSTENI, with which however the subquadrate parallel-sided shape of that cell in some species indicates affinity. Further, some species, evidently closely related to *Oneilella*, which we have examined but excluded from the present paper on various grounds, should apparently be placed in the MESOSTENI. On the other hand the parallel-sided areolet is found also in the HEDYCRYPTINI, and with this tribe *Oneilella* agrees in other characters. It may ultimately prove to be the case that *Oneilella*, as at present understood, contains heterogeneous elements in which the respective generic characters have become weakly marked. But against this is the fact that the species intergrade where characters are taken in detail, *e.g.*, in the shape of the areolet, the sculpture and shape of the mesonotum, the sculpture of the propodeon, etc., so that no sharply defined groups exist within the genus.

This being so, we are for the present content to consider *Oneilella* as a genus showing affinities in more than one direction, but not of a decisive nature. The

systematics of the HEDYCRYPTINI need a thorough revision, since the custom of creating genera of convenience now seriously inconveniences any worker in this subfamily.

Genus **Oneilella,** Cam. 1904.

Our repeated and up to the present unsuccessful attempts to define the bounds of *Oneilella* incline us to believe it to be a rather unnatural category. Nevertheless its members, as regards general facies, form an exceedingly compact group, which it is convenient to treat as a genus, although no single character can be quoted for their differentiation. Of the generic characters given by Cameron (4) some appear to us inessential, while others require modification in view of the material we have lately examined. We, therefore, offer the following note on the genus as an indication of the sense in which it is employed in the following descriptions.

Hedycryptines of large to moderate size. Head as a rule ferruginous. Body black to blackish brown, showing more or less dark blue or violaceous metallic reflections. The antennae have a broad pale band at least dorsally in both sexes. Ground-colour of forewing and of the unbanded hindwing blackish with violaceous reflections, which are brilliant in life, but may be dulled or fade entirely later. Anterior wings with a *single* broad clear band (extending from the base of the stigma towards the apex of the hind wing), which is generally completely transverse, but may be incomplete posteriorly, being separated from the extreme margin by a narrower or wider infuscated edging, often paler than the wing on each side. On the abdomen, tergites 5–8 may show a variable amount of creamy margin posteriorly in both sexes, while the tip of the ovipositor sheath (♀) or of the stipes (♂ armature) may also be pale. The legs are uniformly blackish, with some metallic reflections, particularly on the coxae. Antennae in the ♀ with 34–40 joints, in the ♂ with 40–43 (in one species 48) joints. The pale band occupies about 6 joints of the funicle in the ♀ from the 5th or 6th onwards, in the ♂ generally from the 7th.

Head transverse. Clypeus convex, usually with a median apical tooth, which may however be obsolescent. Labrum distinctly exserted, quadrate, the sides and apex gently concave. Mesonotum either short, flat and broad, or narrower, more salient anteriorly and medianly intumescent. In the former case the notauli may be obsolescent or absent when the general surface is closely sculptured, or present and shallow in smoother species. In the latter case the notauli are well developed. Propodeon rather short, descending abruptly to the petiole from about its middle, not evenly sloped from the post-scutellum, with no definite areolation or carinae, although there is sometimes a more or less distinct dividing line, *e.g.* longitudinally below the spiracle when the pleurae are intumescent or between two types of sculpture. Areolet always five-sided but of variable shape according to the inclination of the outer and inner sides to the radius. Legs long and moderately stout, ovipositor variable.

Nearest Genera.

The position of *Oneilella* as thus defined is somewhat isolated. It is nearly approached, superficially at least, by several genera in which the forewings are bifasciate. *Cryptaulax*, Cam., already referred to, is one such genus. Others we have been able to separate, but not to name. *Gabunia* (PIMPLINAE) is a very distinct and not nearly related bifasciate genus easily recognised by the petiolate areolet, the pale hind tarsi, etc. *Cryptoideus*, Ashm., and *Cryptopteryx*, Ashm., are both separated from *Oneilella* by the transversely keeled propodeon.

So far as the description goes, *Cryptus xanthopus*, Brullé, might be an *Oneilella*, but the colour notes given render this extremely improbable. Of the species of *Cryptus* described by Tosquinet we consider that *alacer*,* *corpulentus*, *eugeneus*, *fervidus*, *formosus*, and *vittatus*,* fall within Cameron's genus. The names marked with an

asterisk cover more than one species. *O. alacer, eugeneus,* and *fervidus* are unrepresented in our material: *corpulentus* we believe we have identified; *vittatus* refers in part probably to the form we have named *analis*. Tosquinet's *formosus* does not appear to be the insect so named by Brullé but closely resembles our *brevispicula*. If we add the reputed American *Ateleonotus* and the species now described, *Oncilella* contains some 23 species. The key refers only to such forms as we have personaly examined. We have tabulated the males separately, partly to draw attention to the genitalia and partly because one cannot be certain that in every case the sexes have been correctly correlated. The types of the species described are, where possible, ♀♀, and more weight should therefore be given to the table for this sex.

Interrelationship of the Species.

As the subjoined key to the ♀♀ is mainly artificial, the more natural grouping of the species among themselves may be indicated. (1) *O. analis, nigeriensis, approximata,* and *latifascia,* stand extremely close, and the third and fourth are probably only races of one species. (2) *O. brevispicula, corpulenta,* and *subquadrata,* are again very near to one another, as is indicated by the sculpture and shape of the mesonotum, shape of areolet, wing pattern, etc. (3) The southern species, *angusta, caudata, formosa,* and *inclinata,* show their affinity particularly in the sculpture of the propodeon. We may

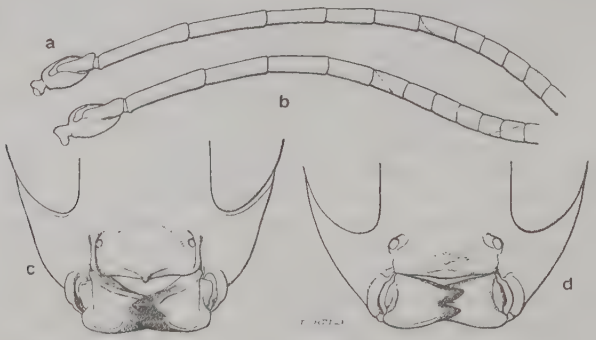

Fig. 1. (*a*) *O. subquadrata,* sp. n., antenna; (*b*) *O. areolata,* sp. n., antenna; (*c*) *O. formosa,* Brul., lower face; (*d*) *O. latifascia,* sp. n., lower face.

note here that the most natural distinction in the genus is between those forms in which the propodeon is clearly, straightly and transversely striate and others in which the striae are incomplete, irregularly bent and interconnected, or with the surface strongly punctate-raised reticulate. As a whole the southern forms are striate, the more northern rugosely reticulate. Exceptions will be noted in the records, but broadly speaking the distinction holds. (4) *O. arcolata, dimidiata,* and *rufopetiolata,* are more isolated forms.

So far as it goes the evidence from the genitalia supports the main divisions made on other grounds. These organs throughout the genus are of a common Ichneumonid type with stipes, laciniae, volsella and spatha, well developed. Between the species the volsellae and laciniae vary chiefly in their dimensions—especially in the breadth and in the number of stiff apical hairs on the latter. For specific determinations their use is probably limited, but the groupings suggested in the key to the ♂♂ appear to be valid.

In the following descriptions, the genotype (*O. formosa*) has been dealt with in detail, and on the other species, for the most part, only a few comparative notes are offered. The types of the forms described are in the British Museum, except in the

case of *O. nigeriensis rugulosa.* Apart from the number of joints, the antennae afford few features of taxonomic value, but the rate of diminution of the joints is somewhat different in *O. areolata* (cf. figs. 1, *a*, *b*). For the separation of the species stress has been laid on the following points : shape and armature of the clypeus ; depth of the notauli and contour of the mesonotum ; form of areolet ; petiole ; length of ovipositor (measured from end of abdomen) ; and the sculpture generally. To a less extent colour has been referred to. The species are arranged in the following sections : (*a*) *formosus* group ; (*b*) *latifascia* group ; (*c*) *subquadrata* group ; (*d*) isolated forms. In group (*b*) the impression left on the mind is of a number of units still progressively developing.

The O. formosa *Group.*

Oneilella formosa, Brullé.

HEAD. *From above.* Strongly contracted behind the eyes ; occiput distinctly concave and carinate, the keel extending down and curving forwards to the base of the mandible. Distance between eyes at level of the anterior ocellus rather less than half the width of the head. Distances between posterior ocelli about two-thirds that of either from the orbit. Breadth of occiput a little over two-thirds the width. Each posterior ocellus flanked externally by a short lunar furrow ; ocellar triangle obtuse anteriorly. Eyes slightly longer (6 : 5) than the occiput at side. Vertex a little swollen behind the posterior ocelli and descending abruptly to the occiput. Surface generally smooth with a few scattered punctures, which are larger and more numerous within or near the ocellar triangle. *From in front.* Eyes as long (deep) as $\frac{3}{4}$ the depth of the head, inner orbits very slightly convergent ventrally, emarginate a little for about one-third their length just below the ocelli ; orbital furrow and carina defined to eye base. Face between toruli and ocelli deeply excavated, with a slight central ridge immediately above the toruli, and the upper half of the hollow irregularly rugulose medianly, below the anterior ocellus. *Lower face* (fig. 1, *c*) slightly swollen medianly with numerous punctures, dull, nowhere strongly showing.

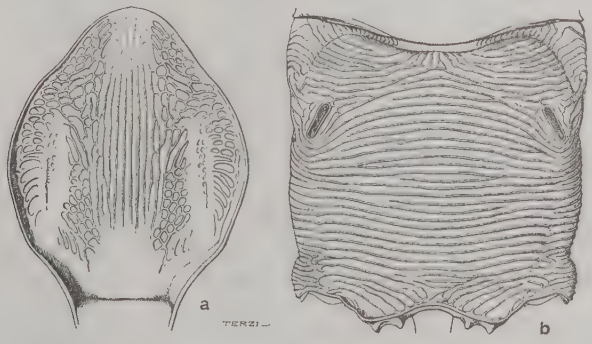

Fig. 2. *Oneilella formosa,* Brul. : *a*, mesonotum ; *b*, propodeon.

Punctures medianly stronger and sparser. *In profile.* Genal space long, from the anterior angle of the mandible to the eye about as long as the basal breadth of the mandible. Immediately behind the slightly raised lateral margin of the clypeus, the genal space is for a short distance (rather less than half the width of the mandible) finely punctate and dull. Beyond this the genae and the occiput are like the vertex, *i.e.* polished and very sparsely punctate. *Clypeus* transversely swollen on upper half, apically truncate, with subconcave convergent sides, closely set with longish bristles especially near apex ; median ventral tooth strong, shining, with only a few punctures. Mandibles strongly punctate externally.

Thorax. *Prothorax* dorsally rugose-punctate in front and crenulate behind; flanking the mesoscutum are 4–5 irregular quadrate depressions, and immediately below these the propleurae are narrowly rugose-punctate, the greater part of their surface with about 20 horizontal parallel ridges (*cf.* propodeon) with only a few scattered punctures between; antero-ventrally the rugae are irregular. *Mesothorax* (fig. 2, *a*). Scutellum deeply divided from scutum by a broad shining sulcus, shining, with one or two strong punctures dorsally and at sides, crenulate above metanotum (post-scutellum). Mesopleurae with strong rugose punctate sculpture; the rugae numerous, waved, or otherwise irregular, but more or less parallel and interconnected. Upper area of episternite shining, with only a few punctures, and the furrow below strongly crenulate. Epimera narrow, nearly linear. Epomiae and sternum strongly punctate and dull. The "cryptive furrow" well developed, strongly crenulate. *Metanotum* medianly smooth, strongly crenulate at sides. *Propodeon* (fig. 2, *b*). Metapleurae and sides of propodeon like dorsum in sculpture, but below the radix of the hind wings, with a triangular shining area defined by a crenulate sulcus which runs downwards to near the insertion of the hind coxae. *Wings.* (for neuration see figs. 3 and 5, *b*). *Legs.* Hind coxae strongly and rather closely

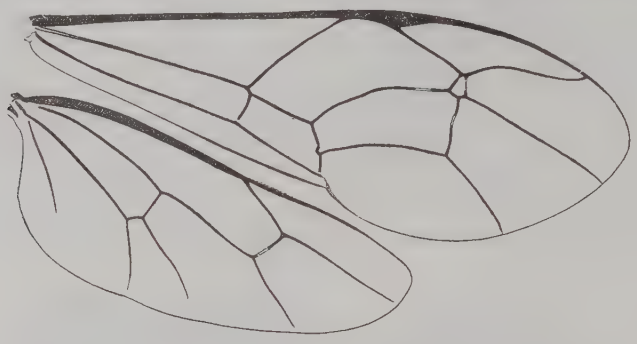

Fig. 3. *Oneilella formosa*, Brullé, wings.

punctate; hind tibiae inwardly decurved on proximal half. *Abdomen* medianly stout. Petiole (fig. 4, *a*, *b*) with the tergites smooth and shining in middle but with an exceedingly fine reticulate pattern (× 40). Punctuation medianly weak and sparse, but stronger and denser towards the sides, and even more pronounced on sternites. Ovipositor robust, as long as hind tibia. Male genitalia (fig. 6, *b*, *c*).

Length: body, 22 mm.; ovipositor, 9 mm.; alar expanse, 44 mm. in larger example.

Cape Province: Annshaw, 1♀, 1897 (*Miss Barrett*); Grahamstown, 1♂, on fennel, xii.1901; East London, 1♀, 15.xii.1916 (*Dr. Bruce*); Port St. John, Pondoland, 1♀, xi.1923 (*R. E. Turner*). Natal: Durban (*teste* Cameron).

In Nyasaland there occurs a variety of this species in which the rugae of the posterior aspect of the propodeon are more or less shortly connected.

Nyasaland: Mt. Mlanje, 1♀, 15.x.1912 (*S. A. Neave*); Zomba, 1♂, 2♀♀, xii.1913, i.1914 (*H. S. Stannus*).

Oneilella inclinata, sp. n.

Antenna 34 joints (Nyasaland ♀). Expanse 32 mm.; body 16–17 mm.; ovipositor 8–9 mm.

Distinguished by (*a*) smaller size, (*b*) areolet (fig. 5, *c*), (*c*) non-projecting petiolar spiracles, and (*d*) ovipositor quite definitely longer than hind tibia. In all the specimens the sculpture of the propodeon is as in *formosa*.

NATAL: 1♂, 1856 (*Plant*); Durban, 1855, 1♂, 1♀ (*Guienzius*—type). N.E. RHODESIA: On road from Fort Jameson to Landazi, 4,000 ft., 7–14.vi.1910, 1♀ (*S. A. Neave*). NYASALAND: Monkey Bay, L. Nyasa, 30.v.1913, 1♀ (*W. A. Lamborn*); Zomba, i.1914 and 1917, 2♀♀ (*H. Stannus*); Mt. Mlanje, 15.xi.1912, 1♀ (*S. A. Neave*).

Oneilella caudata, sp. n.

♀. Expanse about 40 mm.; body about 20 mm.; ovipositor 12–13 mm.

Clypeal tooth strong and blunt. Transverse ridges of propodeon not so clearly cut as in *formosa*, and with a small reticulate area postero-medianly.

NATAL: 1♀, in cocoon of *Anaphe reticulata*, 25.v.1868 (*A. G. Latham*); Illovo R., 10.x.1916, 1♀; Umbilo, Durban, 2♀♀, 8.x.1912, 5.x.1914 (*A. L. Bevis*). TRANSVAAL: Pretoria, 1♂, 10.xii.1916.

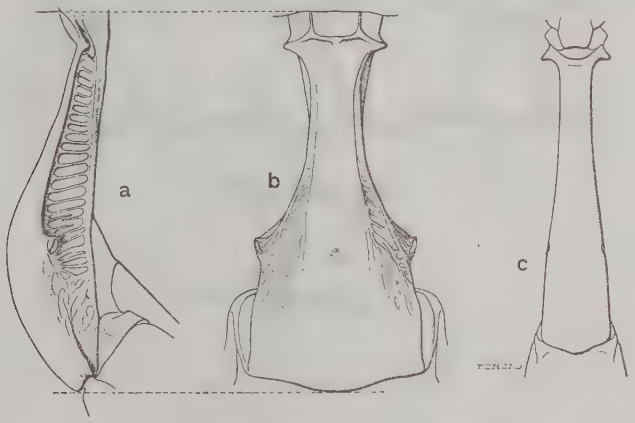

Fig. 4. Petiole of *O. formosa*: *a*, lateral view; *b*, dorsal view; *c*, petiole of *O. rufopetiolata*, dorsal view.

Oneilella angusta, sp. n.

♀. Expanse 30 mm.; body 14 mm.; ovipositor 8 mm.

Clypeal tooth distinct. Mesonotum rugulose, with the usual shining areas. Petiole gradually expanded. Spiracles not prominent. Surface of tergites and petiole dully shining, finely reticulate.

Distinct because of the narrow band of forewing, and the petiole.

NATAL: Tongaat, 1909, 1♀ (*M. C. Burnup*—type).

The O. latifascia *Group*.

This is the most difficult section of the genus. In the key the forms are somewhat unnaturally separated. As noted above, *approximata* and *latifascia* seem to be merely races (whether geographical or host is not at present clear) of one species. The same may be said of *rugulosa* and *nigeriensis*. Difficulty may be felt in using the

key from the fact that the *latifascia* group tend to have the propodeal surface striate anteriorly, especially at the sides. In cases of doubt both branches of the dichotomy may be consulted, but a specimen should be considered as striate only when the entire dorsum is so, except for a small area posteromedianly.

Oneilella latifascia, sp. n. (figs. 5, *a*, and 6, *d*, *e*).

♀. Antenna 36–37 joints. Expanse 37–40 mm.; length of body 18–20 mm.; ovipositor 14–17 mm.

Ocellar lunulae shallow; clypeus (fig. 1, *d*) without a definite tooth, not strongly intumescent. Propleurae with crenulation along edge of mesoscutum, about 12 cells (cf. *formosa*); notauli to well beyond one half; parapsides rugosely punctate near furrows, with besides a few large scattered punctures; mesoscutum with a few large punctures anteriorly along the furrows, more rugose posteriorly between their sides. Sternal furrow coarsely and irregularly punctate, not crenulate.

♂. Antenna 40 joints.

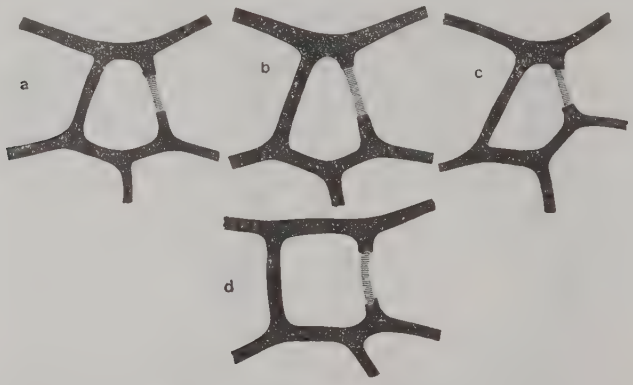

Fig. 5. Areolets of (*a*) *O. latifascia*, sp. n.; (*b*) *O. formosa*, Brul.; (*c*) *O. inclinata*, sp. n.; (*d*) *O. subquadrata*, sp. n.

Uganda: Usukuma or Unyamwedzi, 1893, 5♂♂, 8♀♀ (type), from cocoons of *Anaphe* sp. (*F. C. Smith*); 2♂♂, 2♀♀, from nests of *A. panda*; Mabira Forest, Chagwe, 3,500 ft., 16–25.vii.1911, 1♂ (*S. A. Neave*); Buddu, L. Victoria, 3,700 ft., 19–25.ix.1911, 1♂, 5♀♀ (*S. A. Neave*); Nagunga, 1♂, 21.viii.1913 (*C. C. Gowdey*); Kampala, 1♀, viii.1925, 1♂, 17.ix.1926 (*G. L. R. Hancock*). Nyasaland: Nyika Mts., 6,000–7,000 ft., vii.1896, 1♂, 1♀ (*A. Whyte*). Belgian Congo: 150–200 miles W. of Kambove, 3,500–4,500 ft., 1♂, 31.x.1907 (*S. A. Neave*); Banana, 2♂♂, 3♀♀, from nest of *Anaphe infracta*, iv. 1910 (*Dr. Etienne*); Banana, 2♂♂, 1♀, from nest of *Anaphe venata*, 1910 (*Dr. Etienne*); Kisantu, 2♂♂, 2♀♀, 7–8.v.1915 (*P. Gillet*); Eala, 7♂♂, 2.vi.1914, xi.1917, iv.1919 (*R. Mayné*); Kunzulu, 1♂, ix.1917 (*R. Mayné*). Madagascar: 2♀♀ (probably representing a distinct race).

Oneilella approximata, sp. n.

Antenna, ♀ 37 joints, ♂ 40 joints. Expanse 36 mm.; length of body 18 mm.; ovipositor 16 mm.

In spite of the presence of the clypeal tooth, the close relationship of this form with *latifascia* is indicated by the broad band of the forewing.

UGANDA: Entebbe, 1♂ viii.1912, 2♀♀ xi.1912, 1♂ 16.i.1913, 1♂ 3.vii.1913 (*C. C. Gowdey*); Mabira Forest, Chagwe, 3,500–3,800 ft., 1♀, 16–25.vii.1911 (*S. A. Neave*). CONGO: 1♂ (*Dr. Laman*, Stockholm Mus.).

Oneilella analis, sp. n.

♀. Antenna 36–38 joints. Expanse 30–36 mm.; length of body 15–20 mm.; ovipositor 14–16 mm.

♂. Antenna 42–43 joints.

Similar to *latifascia* but usually with the colour differences noted. The 2nd tergite more shining and the hyaline band of the forewing slightly narrower, more

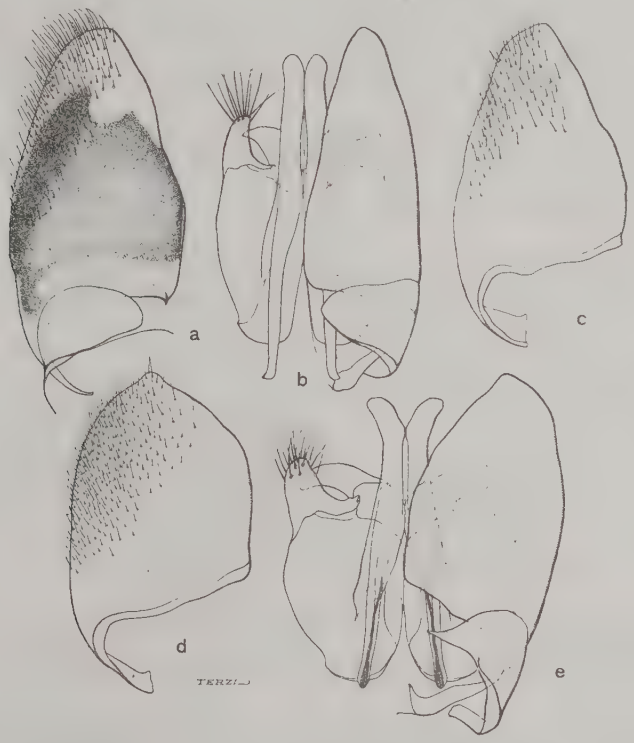

Fig. 6. Male genitalia of *Oneilella*: *a*, stipes of *O. brevispicula*, sp. n.; *b*, genitalia of *O. formosa*, Brul.; *c*, stipes of *O. formosa*; *d*, *e*, stipes and genitalia of *O. latifascia*, sp. n.

parallel-sided behind the areolet, while the whole forewing is apparently less ample. A small but well marked tooth is present on the clypeus, which is strongly intumescent.

S. NIGERIA: Ibadan, 22♂♂, 15♀♀, taken in most months of the year, some of the specimens bred from *Anaphe moloneyi* (*A. W. J. Pomeroy*); Lagos, 2♂♂ (*G. C. Dudgeon*). N. NIGERIA: Yola Province, many ♂♂ and ♀♀ from nests of *A. moloneyi*.

Holotype a ♀ from Yola Province.

Oneilella dimidiata, sp. n.

♂. Antenna 40 joints. Expanse 25–26 mm.; length 13–14 mm.

The apical tooth of the clypeus is well developed. This is possibly a dwarfed form of *approximata* as the first tergite is finely reticulate between the punctures. The post-petiole is about twice as long as the breadth across the spiracles.

UGANDA: Entebbe, 5–25.iv.1914, 5♂♂ (*C. C. Gowdey*).

Oneilella nigeriensis, sp. n.

♀. Antenna 37–39 joints. Expanse 40–42 mm.; body about 20 mm.; ovipositor 11–12 mm.

Clypeal edge at most slightly concave, more or less bluntly elevated in middle but without a pointed tooth. Mesoscutum coarsely punctate-rugulose, the parapsides broadly (in middle) and the mid lobe more narrowly, smooth and shining. Notauli practically obsolete, post-petiole transverse, with prominent spiracles. Abdomen shining, wider than thorax. Ovipositor stout and straight, as long as the hind tibia and 1 or 2 tarsal joints.

The mid lobe of the mesoscutum is more or less rufescent or castaneous anteriorly. The hyaline band of the forewing very broad, and tergites 6–7–8 of abdomen pale edged.

This species is more stoutly built than *latifascia* and with more developed sculpture.

S. NIGERIA, Ekiti, 6♂♂, 6♀♀, 24.xi.1920, ex larvae of *Anaphe venata* (*A. W. J. Pomeroy*); Ibadan, 2♀♀, 9–11.iv.1923 (*A. W. J. Pomeroy*).

Oneilella nigeriensis race **rugulosa,** nov.

♀. Antenna 39–40 joints. Expanse 42–43 mm.; body 19–20 mm.; ovipositor 13–14 mm.

Distinguished from the Nigerian form only by the length of the ovipositor. Though slight in actual measurement, the difference is easily appreciated by the eye. In both forms the prominent petiolar spiracles are thrown into further relief by heavy punctures.

CONGO: Eala, 4♀♀, 20.xi.1917 (*R. Mayné*—Musée du Congo Belge).

Oneilella contracta, sp. n.

Antenna, ♀ 33 joints, ♂ 42 joints. Expanse 35–39 mm.; body 16–19 mm.; ovipositor 6–7 mm.

This is a distinct species, known at once by the narrow areolet, peculiar clypeus, moderate size and short ovipositor. The surface of the abdomen though shining is finely raised reticulate, not smooth, and the punctuation decided on tergites 2 and 3. On the former is an apical belt of heavier impressions in addition to the usual ones near the sulcus.

In both sexes the clear band of the forewing is very broad, the apical cloud posteriorly quite clear of the anal vein.

ABYSSINIA: Atbara, 1876, 1♀. ERITRAEA: 1♀ (*Iwarson*—Stockholm Mus.). UGANDA: Ruwenzori, 10,000 ft., 1♀, 17.v.1911 (*C. C. Gowdey*); between Jinja and Busia or Mbwagos, E. Busoga, 3,800–4,000 ft., vii–viii.1911, 1♂, 3 ♀♀ (*S. A. Neave*—type).

Oneillella robusta, sp. n.

♀. Head. Below the anterior ocellus the usual linear keel is greatly developed ; in profile triangular and prominent flanked by 3–4 ridges curving towards the orbits. Clypeus, edge strongly convex, subangulate, produced flatly below the intumescent area, the flat portion with some heavy punctures ; tooth strong and prominent. There are numerous strong punctures on the genae posteriorly bordering the keel. Antenna with 38 joints.

Thorax. Sculpture everywhere strongly raised except below the forewing radix. Propleura below the crenulation bordering the mesonotum closely set with large punctures to about one-third the depth ; its hind area with numerous strong ridges, punctate between ; ventrally rugulose. Mesonotum practically all rugulose punctate, the pattern close ; usual three glabrous bands indicated only and obsolescent. Prepectus and upper half of mesopleura strongly ridged. Ventrally the mesopleurae are densely punctate. Sternal furrow deep, with somewhat larger punctures, but not definitely crenulate. Scutellum with numerous large deep punctures all over. Propodeon closely rugulose punctate, the rugae very short for the most part, but larger laterally.

Wings. In forewing the recurrent is received a little *beyond* the middle of the cell. Median clear area narrow, not reaching hind edge. Apical dark area broad, cutting the radius (3rd abscissa) at about one-fourth and the cubital at about one-fifth from areolet, and the median at about half-way between the discocubital and the wing margin.

Abdomen. Petiole expanding distinctly towards the somewhat prominent spiracles, with two low keels, one on each side above the ridge running to the spiracles. These keels are quite evident from about halfway from the base ; between them the surface is dull and coriaceous, outside the keels coarsely rugulose, and between the spiracles rugulose coriaceous. Post-petiole, slightly longer than the distance between the spiracles, coriaceous on proximal half and more shining with numerous close-set (6–10) rows of large punctures distally. Second tergite punctate all over, the interspaces swollen on the distal half but more coriaceous proximally, where also the punctures are large.

Expanse 44 mm. ; body 24 mm.

Belgian Congo : S. E. Katanga, 4,000 ft., 1♀, 11.xii.1907 (*S. A. Neave*—type). Uganda : Siroko R., near W. foot of Mt. Elgon, 3,600 ft., 1♀, 12-14. viii.1911 (*S. A. Neave*).

The Uganda specimen is apparently also referable to this species though differing slightly in detail.

Oneillella linearis, sp. n.

Head. Antenna with 38 joints ; the funicle from the tip of the 9th (11th) joint to the middle of the 14th (16th) pale creamy white. Clypeal tooth strong.

Thorax. Propleurae with about a dozen short ridges on lower two-thirds, smoother above save for the usual marginal punctures. Mesonotum strongly rugulose —the pattern large ; parapsides on outer two-thirds and scutum indefinitely along the mid line anteriorly, smooth and shining. Scutellum with numerous punctures. Prepectus punctate rugose. Upper half of mesopleurae with a strong ridge, ventrally like prepectus, but in front of the shining mesepisternite the pleura is smoother and again antero-ventrally. Sternum simply punctate. All the furrows crenulate ; metapleurae punctate and shining. Propodeon entirely rugulose, the pattern coarser posteriorly.

Wings. Areolet very slightly contracted on radius ; recurrent received near the 2nd transverse cubitus on the distal fourth of the cubital abscissa, so that the whole areolet appears subquadrate.

Abdomen. Petiole narrow, expanding rather abruptly at the prominent spiracles ; in profile crenulate, with indications of two slight keels between the spiracles extending shortly both anteriorly and posteriorly ; upper surface posteriorly subcrenulate at sides between the keels and edges and irregularly punctate, rather dull. Post-petiole elongate, half longer than width at spiracles, and only slightly (about one-ninth) broader ; sides slightly swollen, on basal half sculptured like apex of petiole, and with only one or two large scattered punctures posteriorly. Second tergite rugulose-coriaceous basally, then with scattered punctures which tend to form regular rows on distal third. Succeeding tergites smooth, the hair bases not impressed.

British Sudan : Darfur Province, Murnya, 1♂, vii. 1921 (*Admiral H. Lynes*).

The only *Anaphe* taken by Admiral Lynes from this locality has been identified as *A. ambrizia*, Butl.

The O. subquadrata *Group.*

This division of the genus is easily recognisable by (*a*) the peculiar areolet ; (*b*) the generally dense strong sculpture (the second and third tergites in particular completely

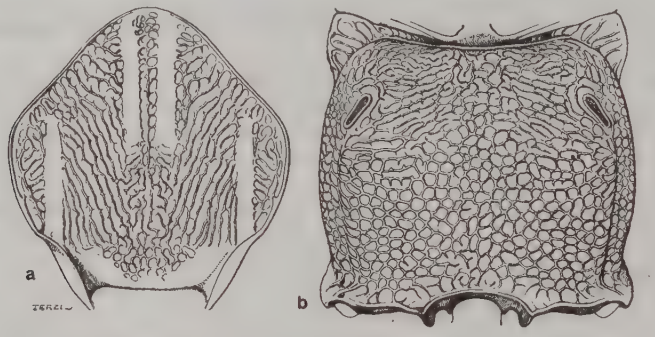

Fig. 7. *Oneilella brevispicula*, sp. n. : *a*, mesonotum ; *b*, propodeon.

and closely set with heavy punctures) ; (*c*) the slightly longer genae, which just exceed the basal width of the mandible ; and (*d*) the vertex sharp rugulose between lateral ocelli and orbits.

Oneilella brevispicula, sp. n. (fig. 6, *a*).

Antenna, ♀ 34–36 joints, ♂ 42 joints. Expanse 39–45 mm. ; body 18–26 mm. ; ovipositor 7–11 mm.

Clypeus somewhat flattened ; tooth obsolescent. Mesoscutum and propodeon (fig. 7). Tergites 4–7 covered densely with punctures only a little finer than those on 2 or 3. The ovipositor is merely a little longer than the hind tibia. The colour of the thorax and abdomen is rich dark blue to violet.

In the large ♀ (45 mm.) from Mabira Forest the ovipositor is somewhat longer and the band of the forewing broader than in the typical Uganda series.

Uganda : Mbale—Kuni Road, 3,700 ft., S. of Lake Salisbury, 7♂♂, 6♀♀ (type), 15–17.viii.1911 (*S. A. Neave*) ; between Kumi and N.E. shore of Lake Kioga, 3,400–3,600 ft., 2♂♂, 18–20.viii.1911 (*S. A. Neave*) ; Mabira Forest, 1♀ (very large),

3.vii.1913 (*C. C. Gowdey*); Wema I., Lake Victoria, 1♂, 25.ii.1914 (*G. D. H. Carpenter*); Kisigalla I., Lake Victoria, 1♀, 24.vii.1918 (*Carpenter*). BELGIAN CONGO: Congo da Lemba, 2 ♀♀, i.1913 (*R. Maynè*), 1♀, x.1913 (*R. Verschueren*); Kolo-Kwilu-Madiata, 1♀, ix.1913 (*R. Verschueren*); Elizabethville, Lulrumbrashi, 1♀, 23.v 1920 (*Dr. J. Bequaert*); Eala, 1♀, iv.1921 (*Lt. Ghesquière*).

Oneilella subquadrata, sp. n. (fig. 5, *d*).

Antenna (fig. 1, *a*), ♀ 36 joints, ♂ 42 joints. Expanse, ♀ 32–40 mm.; length 18–20 mm.

Very like *brevispicula* but not attaining so large a size. A duller insect. In addition to the colour differences in the key, one notes that in *brevispicula* the post-petiole is quadrate or slightly transverse with prominent spiracles, and the heavy punctures of tergites 2 and 3 are on the average separated by not more than their own diameter, while in *subquadrata* the post-petiole is about one-half longer than broad across the hardly projecting spiracles, and the punctures are more diffusely placed.

CONGO: Etshushu, 1♂, x.1912 (*R. Maynè*—Mus. Congo Belge). UGANDA: Entebbe, 1♀, 6.vii.1911, ♂♀, 24–25.v.1913 (*C. C. Gowdey*—type); Mavera, Entebbe, 1♀, 26.vii.1912 (*C. C. Gowdey*); Mabira Forest, 1♀, 3.vii.1913 (*S. A. Neave*); between

Fig. 8. *Oneilella areolata*, sp. n., mesonotum.

Jinja and Busia or Mbwagos, E. Busoga, 3,800–4,000 ft., 1♂, vii.–viii.1911 (*Neave*); Siroko R., N.W. foot of Mt. Elgon, 3,600 ft., 12–14.viii.1911, 1♀ (*Neave*); Semliki Plains, nr. S. shore of L. Albert, 2,200 ft., 1♂, 25–27.xi.1911 (*Neave*). KENYA COLONY: Nyangori, N. Kavirondo, 4,800 ft., 1♂, 18–19.v.1911 (Neave); Ilala, Maramas Dist., 14 miles E. of Mumias, 4,500 ft., 1♀, 18–21.vi.1911 (*Neave*). N.W. RHODESIA: Chilanga, 4,000 ft., 1♀, 6.x.1913 (*F. V. Bruce Miller*). NYASALAND: Mt. Mlanje, 2,300 ft., 2♂♂, 1.ix.1913 (*S. A. Neave*); 1♂, 8.x.1919. S. RHODESIA: 1♂, 1894. TRANSVAAL: Lydenberg District, 1♀ (*W. L. Distant*).

Oneilella corpulenta, Tosq.

Antenna, ♀ 33 joints, ♂ 40–41 joints. Expanse 28–40 mm.; body 17–20 mm.; ovipositor 8–10 mm.

Recognisable at once from the wing pattern; otherwise very like *subquadrata*.

In the ♂ the puncturation is heavier and denser than in ♀, resembling in this respect *brevispicula*.

DAHOMEY: Whydah, 2♂♂, 1853 (*Louis Fraser*). S. NIGERIA: Lagos, 1♀, 1899 (*Dr. H. Strachan*). CONGO: Okondo, Uele R., 1♂, 1♀, 7.vii.1914 (*Dr. Rodhain*—Mus. Congo Belge).

Oneilella areolata, sp. n.

Antenna (fig. 1, *b*), ♀ 36 joints, ♂ 42 joints. Expanse 38 mm.; body 17–18 mm.; ovipositor 12–13 mm.

Clypeus with large angular tooth (cf. *contracta*). Mesoscutum (fig. 8) smooth and almost impunctate save near the notauli. Mesopleurae in middle smooth and shining along whole length, with large punctures anteroventrally and a few ridges above; prepectus smooth, without large punctures though with numerous minute bristles; propodeon striate-punctate, the ridges subparallel but interconnected at sides behind spiracles. Abdomen brilliantly smooth and entirely destitute of larger punctures even near sutures; post-petiole very broad, with a lunular impression at each spiracle. Ovipositor slightly curved, subequal to tibia and tarsus.

UGANDA: Damba I., L. Victoria, 9.vii.1911, 3 ♂♂ "flying in numbers round tree-trunk" (*G. D. H. Carpenter*); Mfungano Is., L. Victoria, 1♂, 27.iv.1911 (*S. A. Neave*); Buamba Forest, Semliki Valley, 2,300–2,800 ft., 1♀, 3–7.xi.1911 (*Neave*); Entebbe, 1♀, 1–5.vi.1912 (*C. C. Gowdey*); Bweya, 1♂, 23.v.1913 (*Gowdey*).

Oneilella rufopetiolata, sp. n.

Antenna, ♀ 42–43 joints, ♂ 48 joints. Expanse 31–35 mm.; body 14–17 mm.; ovipositor 5–6 mm.

Head rugulose in front of the ocelli, but broadly smooth near the adjacent orbits; a fine median keel from below anterior ocellus to base line of toruli; clypeus with the median tooth split into two (minute); genal space distinctly shorter than breadth of mandible at base. Mesonotal sculpture as in the *subquadrata* section. The Hedycryptine furrow shallow and short. The propodeon descends rather gradually to the petiole. Wings clear, band not reaching hind margin and extending only narrowly beyond the areolet and recurrent. Hind coxae punctate, striate superiorly. Petiole (fig. 4, *c*); abdomen more densely pubescent than in the other species.

An exceedingly distinct species from its peculiar combination of characters. In the clypeus unlike any other *Oneilella*, and with more joints in the antenna.

NYASALAND: Mt. Mlanje, 2♂♂, 2♀♀, 25.xi.–31.xii.1912, 1♀, 21.xii.1913 (*S. A. Neave*).

Key to the Species of Oneilella.

Females.

1. Terebra at least as long as the hind tibia and tarsus combined 2
   Terebra shorter than the hind tibia and tarsus combined... 6
2. Mesonotum smooth; notauli deeply sunk; the median lobe intumescent
   areolata, sp. n.
   Mesonotum more or less punctate or rugulose; notauli shallow or obsolescent; the median lobe not swollen 3
3. Notauli obsolescent, more or less merged in the general sculpture; mesonotum rugose or rugose-reticulate save for the usual smooth areas (the median one narrow); ovipositor stout, no longer than tibia and tarsus
   nigeriensis rugulosa, subsp. n.
   Notauli well marked to beyond one-half; the general notal sculpture consisting chiefly of heavy punctures with indications of rugae near the ends of the furrows; ovipositor more slender, always definitely longer than tibia and tarsus 4

4. Second tergite rather dull, finely raised-reticulate all over with numerous large shallow punctures ; clypeal edge gently concave, or broadly angled medianly, the angle rounded ; tooth absent or obsolescent *latifascia*, sp. n.
Second tergite shining ; clypeal tooth present 5

5. Mesonotum anteriorly (sometimes entirely) castaneous ; tergites 6–8 (and occasionally 5) pale-edged ; post-petiole about the same width at apex as across spiracles, sides convex ... ... *analis*, sp. n.
Mesonotum black ; tergites 7–8 only pale-edged ; post-petiole about one-third wider at apex than across spiracles ... ... *approximata*, sp. n.

6. Propodeon transversely striate, the hollows between the ridges shining ... 7
Propodeon coarsely reticulate or rugose-reticulate 10

7. Hyaline band of forewing narrow, not extending apically beyond the areolet and the second recurrent nervure ... ... *angusta*, sp. n.
Hyaline band of forewing broader, extending far beyond the areolet and the second recurrent nervure 8

8. Terebra no longer than the hind tibia ; spiracles of the petiole prominent *formosa*, Brul.
Terebra longer than the hind tibia ; spiracles of the petiole not prominent 9

9. Terebra only a little shorter than the hind tibia and tarsus combined ; inner and outer sides of areolet equally inclined ... ... *caudata*, sp. n.
Terebra much shorter than hind tibia and tarsus combined ; inner side of areolet much more oblique than outer ... ... *inclinata*, sp. n.

10. Outer and inner sides of areolet subparallel 11
Areolet contracted on the radius 13

11. Thorax dark blue ; hyaline band on forewing reaching to the posterior margin *brevispicula*, sp. n.
Thorax black ; hyaline band of forewing not touching the posterior margin 12

12. Dark ground-colour of forewing extending from the base to the areolet and the second recurrent nervure ... ... *corpulenta*, Tosq.
Hyaline band of forewing extending basally far beyond the areolet and second recurrent nervure ... ... *subquadrata*, sp. n.

13. Tergites without white ; inner side of areolet more oblique than outer ; petiole very narrow to the apex ; scarcely broadened behind the spiracles *rufopetiolata*, sp. n.
Seventh tergite broadly, eighth narrowly white apically ; areolet normal 14

14. Ovipositor not longer than hind tibia ; post-petiole longer than breadth across spiracles ; clypeus comparatively flat or very slightly swollen and produced insensibly into a prominent angular tooth ; areolet small and anteriorly narrowed ... ... *contracta*, sp. n.
Ovipositor at least as long as hind tibia and 1st tarsal joint ; post-petiole transverse ; clypeus distinctly swollen above the oral edge ; areolet variable 15

15. Clypeal tooth strong ; sculpture generally heavier ; petiole and second tergite dull, the latter with close dense somewhat large punctures ...*robusta*, sp. n.
Clypeal tooth obsolescent ; sculpture normal ; abdomen shining ; 2nd tergite with denser puncturation at most near the sutures laterally *nigeriensis*, sp. n.

Males.

1. Stipes broadly white apically ; areolet subquadrate 2
Stipes not white apically ; areolet not subquadrate 4

2. Dark ground-colour of forewing extending from the base to the areolet and to the second recurrent nervure ... ... *corpulenta*, Tosq

Hyaline band of forewing extending basally far beyond the areolet and second recurrent nervure 3

3. Thorax dark blue ; apex of first tergite nearly twice as broad as the petiole between the spiracles ... ... *brevispicula*, sp. n.
Thorax black ; apex of first tergite only half as broad again as the petiole between the spiracles ... ... *subquadrata*, sp. n.

4. Stipes very large, broad, shining and opaque, symmetrical about the apex 5
Stipes not unusually large, thinner, more or less transparent, apex variable, the sides more or less asymmetrical 6

5. Mesonotum red anteriorly ; a narrow white apical line on the fifth tergite *analis*, sp. n.
Mesonotum and fifth tergite wholly black ... ... *latifascia*, sp. n.

6. Notauli deep, long, extending beyond the middle of the mesonotum, median lobe of mesonotum smooth and intumescent ... ... *areolata*, sp. n.
Notauli shallow or obsolescent, median lobe of mesonotum neither intumescent nor wholly smooth 7

7. Femora with a pale basal ring ; petiole scarcely broadened posteriorly *rufopetiolata*, sp. n.
Femora concolorous, black ; petiole more or less distinctly broadened posteriorly 8

8. Propodeon transversely striate, the space between the ridges smooth and shining 9
Propodeon reticulate, or if striate, then with connecting rugae between the ridges 10

9. Spiracles of the petiole prominent ; petiole rather strongly broadened behind the spiracles ... ... *formosa*, Brul.
Spiracles of petiole not prominent ; petiole only slightly broadened behind the spiracles ... ... *inclinata*, sp. n.

10. Sixth tergite with white apically ... ... *contracta*, sp. n.
Sixth tergite without white 11

11. Mid lobe of mesonotum with distinct longitudinal striae postero-medially *approximata*, sp. n.
Mid lobe of mesonotum without striae, almost smooth, with sparse punctures, mostly along the notauli *dimidiata*, sp. n.

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PARASITES AND HYPERPARASITES OF *DIATRAEA SACCHARALIS* IN TUCUMÁN SUGAR-CANE.*

By Dr. Juan Brèthes,
Professor in the University of La Plata.

In the Revista Industrial y Agrícola de Tucumán of November 1923 to January 1924, 4th year, numbers 6–8, Arthur H. Rosenfeld & T. C. Barber published an interesting article on the sugar-cane moth borer, known in Tucumán as the " gusano chupador de la caña de azucar," in which they detail the different effects of the said moth borer (*Diatraea saccharalis*).

Last year, Dr. William E. Cross, Director of the Estación Industrial y Agrícola de Tucumán, was good enough to entrust me with the study of some *Diatraea* parasites, the identification of which had, so far, only been effected generically.

My best thanks are due to Dr. Cross for having supplied me with material for this investigation, which I consider very interesting, owing to the daily increasing importance of the biological control of agricultural pests.

There is no doubt but that by continuing these investigations other parasites will be discovered ; this is as yet only the first step on the road which may lead to very important results.

The parasites and hyperparasites discovered are :—

Microdus crossi, sp. n.
Ipobracon tucumanus, Brèthes.
Aulatopria tucumanus, gen. n., sp. n.
Sarcophaga diatracae, sp. n.

Microdus crossi, sp. n.

Ferrugineus ; capite nigro, antennis piceo-nigris, funiculo plus minus tertio basali obscure ferrugineo ; partibus oris et labro ferrugineo-testaceis ; tarsis apicem versus gradatim piceis. Alis subhyalinis, tertio apicali fusco, stigmate et regione proxima flavis ; alis posticis dimidio apicali infumato. Terebrae valvis nigris. Long., 9 mm. ; antennae, 6 mm. ; alae, 8 mm. ; terebra, 12 mm.

Head shiny, finely punctate and with fine pubescence. Two subvertical impressions on the face, the lower being the deeper ; one slight impression at top of face towards antennae ; a subhorizontal impression between the antennae and the ocelli. Cheeks of same height as vertical diameter of eyes. Second joint of funicle manifestly longer than the succeeding one, which is subequal to those following. Thorax rather finely punctate and with greyish pubescence, more glabrous on the median lobe of the mesonotum and even more so on the propleurae. Wing sclerites subflavous. Median segment shorter than wide, the upper portion a little elevated and limited on either side by a suprastigmal crest ; in the middle longitudinally the punctation is subareolate, overlapping to where the sides are smooth. Abdomen with the first segment widening towards the extremity ; stigma (spiracle) situated anteriorly ; upper surface excavated basally, the borders forming a crest and uniting on the median line posteriorly ; on either side of the middle crest the surface is irregularly reticulated, except posteriorly, where it is subglabrous. Second segment glabrous, with the fore angles striately impressed ; median transverse impression also striate but not very distinctly. Third segment smooth, with median transverse area simple. Rest of segments glabrous. Wings subhyaline as far as the front of stigma,

* Being a Scientific Contribution from the Agricultural Experiment Station, Tucumán, Argentina. Translated and reprinted by permission of the author from *Revista Industrial y Agrícola de Tucumán*, xvii, nos. 7–8, pp. 163–166, Dec. 1926–Jan. 1927.

costa smoky to a little way beyond stigma ; first cubital, areola, commencement of radial, and commencement of third discoidal, hyaline ; rest of wing blackish brown.

I take great pleasure in dedicating this species to Dr. W. E. Cross, whose investigations on sugar-cane, and sugar-cane mosaic disease in particular, have been so highly appreciated by those who are informed on these matters.

Ipobracon tucumanus, Brèthes.*

Mixed with the *Microdus crossi* were also some specimens of *Ipobracon tucumanus*, the external aspect of which is very similar to the former ; but the circular aperture between the clypeus and the mandibles, the form of the second cubital cell, the median segment being differently shaped, etc., all tend to make it easy to distinguish these two insects.

It will be necessary to add *Ipobracon tucumanus* to the list of the parasites of *Diatraea saccharalis*.

Aulatopria, gen. n.

Caput sphaericum. Oculi minuti, rotundati, laterales. Ocelli 3, in triangulum positi. Antennae 13-articulatae, in medio frontis insertae, scapo apicem versus subclavato et modice arcuato (♀), articulis 2 primis funiculi subaequelongis, articulis 3 sequentibus brevibus, moniliformibus, dein clava 7-articulata vix basi antennarum subaequelonga ; (♂) articulo secundo primo funiculi longiore, tertio primo subaequali, ceteris apicem versus sensim clavam formantibus. Thorax oblongus antice posticeque attenuatus, mesonoto haud sulcato, scutello subquadrato, haud foveolato, segmento medio postice truncato, supra in medio denticulo minuto armato. Alae anticae vena subcostali a tertio marginis alarum attingente ; posticae modice fimbriatae. Abdomen oblongum, ovatum, breve petiolatum, extus haud carinatum. Pedes normales, femoribus tibiisque subclavatis, unguibus simplicibus. Corpus pedesque sparse et modice longe setulosi.

This genus can be well distinguished from *Diapria* by its antennae, which have 13 joints in both sexes in place of 12 (female) or 14 (male) ; the scutellum has no hollow at its base, and the petiole of the abdomen, instead of being longer than broad, is on the contrary broader than long.

Aulatopria tucumana, sp. n.

Nigra, antennis, partibus oris, tegulis et pedibus a coxis testaceo-ferrugineis ; alis limpidis. Long., 2 mm. ; alae, 1·90 mm. ; antennae, 1·50 mm.

Entire body covered with rather long scattered rufous hairs. Black, without punctation, shiny. Head globular, eyes small and round, ocelli forming a subequilateral triangle. Antennae with 13 joints in both sexes ; those of female with the last six or seven joints forming a distinct club ; club of the male antennae less distinct and inserted on a level with the upper part of the eyes. Thorax oval ; pronotum clearly visible from above ; mesonotum without impressions ; scutellum subquadrate, slightly narrowing posteriorly, without impressions ; median segment opaque, with a minute tooth behind scutellum. Abdomen oval, narrowed anteriorly and posteriorly ; petiole short, slightly wider than long ; the second segment long, third and succeeding segments short. Wings hyaline, with subcostal vein reaching along costa to about one-third of wing, where it appears to form a small stigma. Without other veins apparent, as likewise posterior wings.

So far as we know at present, the DIAPRIINAE parasitise only Diptera ; in accordance with this both Rosenfeld and Barber have observed *Aulatopria tucumana* parasitising the following species of *Sarcophaga*.

* An. Mus. Nac. Hist. Nat. Buenos Aires, xxiv, p. 60 (1913). Described as an *Iphiaulax*.

Sarcophaga diatraeae, sp. n.

Grisescens, capite antice modice aureo-tomentoso, postice griseo. Antennis ferrugineis, articulo tertio maxima ex parte obscuriore. Palpi testaceo-ferruginei. Thorace lineis 3 nigris dorsalibus, abdomine segmentis (♀) 1–3 linea media et altera supero-laterali tantum obliqua ornatis, (♂) segmentis 1–3, quartoque basi, obscuris, secundum lucem plagis grisescentibus tantum notatis. Tegulis albis. Halteribus piceis, clava apice alba ; segmento quarto plus minus dimidio apicali et hypopygio rufulis. Pedibus nigris. Long., 6·9 mm.

Front at vertex about one-fifth or one-sixth (♂) or one-third (♀) width of head. Frontal band blackish, broadening gradually towards base of antennae ; integument of bands ferruginous in front with golden pubescence. Face with pubescence of whitish gold colour. Post-vertical setae stout, as thick as vibrissae. In the ♂ a line of very fine hairs along the middle of the orbital bands. Antennae situated on a slightly higher level than that of centre of eyes : antennae reddish, the major part of the third joint dark. Palpi ferruginous, proboscis blackish. Occiput with greyish pubescence. Thorax ashy, with three black lines dorsally, the ashy part becoming at times somewhat yellowish posteriorly, as also scutellum, which is a trifle darker in the centre. Abdomen elliptical (♀) or oval (♂), with ashy pubescence, lighter in ♂. In ♂ the first three segments have a narrow black median line, and on either side another slightly oblique line. In ♀ the first three segments and the base of the fourth are darker, with slightly greyish pubescence in middle of each side of each segment, when viewed at a certain angle. Third and fourth segments with marginal macrochetae. Extremity of fourth segment and hypopygium light reddish. Alulae whitish. Halteres blackish, extremity of club white. Wings greyish hyaline, base of third longitudinal vein bristly ; no costal spine. Small cross-vein in front of middle of discoidal cell. Elbow of fourth longitudinal vein slightly appendiculated ; apical cross-vein curving to the half near the elbow and soon afterwards straight; posterior cross-vein slightly sinuous. Legs black, posterior tibiae not pubescent.

The insects I am studying bear the label *Sarcophaga ochropyga,* v. d. W., which however we believe does not agree with them. In effect van der Wulp says of his species, that the dorso-central macrochetae are wanting or hidden below the dense pilosity, being visible only on the sides and the posterior border ; the Tucumán species shows macrochetae all over the dorsal surface. Van der Wulp says that the antennae are black and the tegulae yellowish white ; the Tucumán species has the antennae ferruginous, the third joint being in part darkened, and the tegulae are certainly white.

If we compare specimens from Tucumán with the descriptions of van der Wulp, as published in the Biologia Centrali-Americana (ii, 1896), they correspond better with *Sarcophaga claripalpis*, owing to the distinct dorsal macrochetae, and the third longitudinal vein of the wings being only slightly setose at the base, the hypopygium reddish and the palpi testaceous reddish ; but the Mexican species has no bristles on the veins. Neither can it be identified with *S. rufipalpis*, Mcq., in which the hind tibia of the male is very bristly.

They cannot belong to *S. amata*, Wied., as they do not have the abdomen tessellated ; also *S. suffusa*, Wlk., has some characteristics which do not appear in *S. diatraeae*, for example, the three black lines on the mesonotum, the yellowish border of the tegulae, etc.

COLLECTIONS RECEIVED.

The following collections were received by the Imperial Bureau of Entomology between 1st April and 30th June, 1927, and the thanks of the Managing Committee are tendered to the contributors for their kind assistance :—

Mr. E. Appenhagen :—161 Orthoptera ; from the Canary Islands.

Dr. G. Arnold, Rhodesia Museum :—49 Coleoptera, 20 Parasitic Hymenoptera, and 12 Rhynchota ; from South Africa.

Mr. E. Ballard, Commonwealth Cotton Entomologist : —24 Diptera, 14 Parasitic Hymenoptera, and 17 Rhynchota ; from Queensland, Australia.

Lady Bayly :—7 Coleoptera ; from Italy.

Mr. G. A. H. Bedford :—3 Mites ; from South Africa.

Dr. C. F. C. Beeson, Forest Entomologist :—36 Curculionidae, 46 Rhynchota, and a tube containing galls on *Litsaea polyantha* ; from Dehra Dun, India.

Mr. G. E. Bodkin, Government Entomologist :—42 Lepidoptera ; from Palestine.

Mr. A. J. Brooks, Director of Agriculture :—28 Isoptera and 12 Rhynchota ; from the Gambia.

Dr. P. A. Buxton, London School of Hygiene and Tropical Medicine :—31 Culicidae, 6 *Glossina*, 49 Simuliidae, and 153 other Diptera ; from various localities.

Mr. E. C. Chubb, Durban Museum :—103 Rhynchota ; from South Africa.

Mr. A. Cuthbertson :—39 Diptera and 22 Rhynchota ; from Southern Rhodesia.

Mr. D. d'Emmerez de Charmoy :—13 Diptera, 12 Coleoptera, 100 Chalcididae, and 10 Rhynchota ; from Mauritius.

Dr. P. Dovnar-Zapolsky :—109 Orthoptera ; from the Caucasus.

Miss A. M. Evans, Liverpool School of Tropical Medicine :—35 Isoptera ; from the Gambia.

Mr. T. Bainbrigge Fletcher, Imperial Entomologist :—1,331 Orthoptera ; from India.

Mr. C. French, Junr. :—3 species of Coccidae ; from Victoria, Australia.

Lt. J. Ghesquière :—22 species of Coccidae and 5 packets of Coccidae attacked by fungus ; from the Belgian Congo.

Government Entomologist, Coimbatore :—8 Coleoptera ; from South India.

Mr. C. C. Gowdey, Government Entomologist :—8 Diptera, 46 Coleoptera, 33 Lepidoptera, 1 species of Coccidae, 7 Orthoptera, and 5 Odonata ; from Jamaica.

Mr. E. Hargreaves, Government Entomologist :—54 Diptera, 69 Coleoptera, 23 Hymenoptera, 62 Lepidoptera, 32 Isoptera, 40 Thysanoptera, 11 species of Coccidae, 23 other Rhynchota, 27 Orthoptera, 10 Planipennia, and 2 Trichoptera ; from Sierra Leone.

Mr. H. Hargreaves, Government Entomologist :—44 Culicidae, 62 Coleoptera, 3 Hymenoptera, 323 Lepidoptera, 92 Rhynchota, 2 Orthoptera, 34 Planipennia, 9 Odonata, and 4 Ephemeridae ; from Uganda.

Mr. G. F. Hill :—8 Siphonaptera, 9 Tipulidae, 73 Coleoptera, 10 Hymenoptera, 4 Isoptera, 70 Thysanoptera, 6 species of Coccidae, 5 other Rhynchota, and 18 Mites ; from Victoria, Australia.

Dr. W. A. Hoffman :—14 Coleoptera ; from Porto Rico.

Indian Museum, Calcutta :—1,320 Orthoptera ; from India.

Mr. R. W. Jack, Chief Entomologist :—6 Diptera ; from Southern Rhodesia.

Mr. W. H. de Jong :—6 Lepidoptera ; from Java.

Mr. T. W. Kirkpatrick :—21 Parasitic Hymenoptera ; from Kenya Colony.

Mr. F. J. McCall, Chief Veterinary Officer :—20 *Haematopota* and 41 *Glossina* ; from Tanganyika Territory.

Mr. J. W. McHardy :—5 Culicidae and a slide of genitalia ; from Tanganyika Territory.

Mr. H. M. Morris, Government Entomologist :—30 Diptera, 145 Coleoptera, 176 Hymenoptera, 10 Lepidoptera, and 37 Rhynchota ; from Cyprus.

Mr. R. W. Mungomery :—23 Coleoptera ; from Queensland, Australia.

Prof. G. H. F. Nuttall, F.R.S. :—3 Hippoboscidae ; from Ceylon.

Pacific Biological Laboratories :—2 microscope slides of Culicidae, and 20 Culicidae, 36 larvae, and 36 pupae ; from California.

Mr. R. W. Paine :—2 Coleoptera, 30 Hymenoptera and a number of early stages, 8 Lepidoptera, 6 Rhynchota, and 2 Psocidae ; from the Fiji Islands.

Prof. Guido Paoli :—121 Coleoptera ; from Italy.

Mr. A. H. Ritchie, Government Entomologist :—63 Coleoptera, 57 Hymenoptera, 500 Thysanoptera, 28 species of Coccidae, 7 species of Aphidae, and 54 other Rhynchota ; from Tanganyika Territory.

Mr. R. Senior-White, Malaria Research Officer :—17 Rhynchota, 16 Mites, 7 tubes and 6 slides of Algae, 5 tubes and 1 slide of Entomostraca, 1 tube and 2 slides of Protozoa, 1 slide of Spirochaete, 1 tube of Cladocera, and 1 slide of Diatoms ; from the Punjab, India.

Prof. F. Silvestri :—75 Parasitic Hymenoptera ; from Italy.

Mr. H. W. Simmonds, Government Entomologist :—9 Diptera, 73 Coleoptera, 23 Hymenoptera, 2 Lepidoptera, 2 Thysanoptera, 15 Rhynchota, and 20 Orthoptera ; from the Fiji Islands.

Mr. C. C. Skeete :—14 Chalcididae ; from Barbados.

Mr. C. B. Symes, Medical Entomologist :—1,185 Culicidae, 8 other Diptera, 8 Cimicidae, 216 Ticks, and 15 Mites ; from Kenya Colony.

Mr. T. H. C. Taylor :—6 Diptera, 20 Coleoptera, 145 Parasitic Hymenoptera, 13 Lepidoptera, and 17 Thysanoptera ; from Java.

Mr. H. P. Thomasset :—3 Culicidae, 37 other Diptera, 134 Coleoptera, 48 Hymenoptera, 155 Lepidoptera, 36 Rhynchota, 44 Orthoptera, 9 Planipennia, and 5 Trichoptera ; from Natal.

Mr. F. W. Urich :—19 Chalcididae ; from Trinidad.

Mr. R. Veitch, Chief Entomologist :—55 Rhynchota ; from Queensland, Australia.

Wellcome Tropical Research Laboratories, Khartoum :—690 Siphonaptera, 13 *Glossina* and 4 slides of genitalia, 8 other Diptera, 177 Coleoptera, 68 Lepidoptera, 300 Thysanoptera, 950 Rhynchota, 533 Mallophaga, 280 Anoplura, 9 tubes of Eriophyid Mites, and 120 other Mites ; from the Sudan.

Mr. F. X. Williams :—313 Curculionidae from the Malay Archipelago ; and 35 Hymenoptera from Tropical America.

Zoological Museum, Leningrad :—128 Orthoptera ; from Russia.

THE STRUCTURE OF THE HEAD AND MOUTH PARTS IN *CULICOIDES PULICARIS*, L. (DIPTERA NEMATOCERA).

By B. Jobling.

(*From the Wellcome Bureau of Scientific Research, London.*)

(Plates IX.–XII.)

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Introduction.

In view of the fact that many blood-sucking Diptera are carriers of pathogenic micro-organisms of animals and human beings, the study of the structure of their mouth-parts has attracted the attention not only of zoologists but of medical men as well.

Zoologists are chiefly concerned with the morphology and the homology of the mouth-parts and their bearing on the phylogeny of the species, whereas the medical worker deals with functions in so far as they may be concerned with a transmission of pathogenic diseases. In many cases the medical man is not in contact with the current zoological literature and therefore adopts the old and often incorrect terminology of these parts.

The interpretation of the fixed and movable parts of the head-capsule of the Diptera introduced by Peterson (1916) and Crampton (1921, 1923 and 1925) laid the foundation for a more exact terminology. But, so far as I know, the data obtained by these authors have not been widely used by modern investigators of the mouth-parts of the blood-sucking Diptera. In view of this, having undertaken the study of the life-history of *Culicoides vexans*, Staeg., I decided to investigate the structure of the head-capsule and the mouth-parts of this genus. *Culicoides pulicaris*, L., was selected for this purpose, and in addition *C. obsoletus*, Mg., and *C. vexans*, Staeg., were also examined. Moreover, the structure of the parts was compared with that in the other blood-sucking Nematocera.

The anatomy of the mouth-parts of *Culicoides pulicaris*, L., has been studied by Goetghebuer (1923), Leon (1924) and in some African species by Carter, Ingram & Macfie (1920). Their descriptions are, however, incomplete. A detailed account of the external and internal structure of the head-capsule and the mouth-parts is not only desirable but is of especial interest, since the recent observations of Dyce Sharp (1927) indicate that in *Culicoides grahami*, Aust., is to be found the long-sought

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transmitting host of the parasitic worm *Acanthochilonema perstans*, Mans., in Nigeria.* In the present paper I have omitted descriptions of the fat-body and the respiratory and nervous systems, though some of these parts are shown in the drawings.

For checking my determination of the species of the genus *Culicoides* and for lending me the specimens of *Simulium ornatum* I wish to acknowledge my indebtedness to Mr. F. W. Edwards, of the British Museum (Natural History).

The Head-capsule.

The head-capsule of *Culicoides pulicaris* is rounded anteriorly and posteriorly. The anterior surface of the head (text-figs. 1, A and 2, C) has two projections, one formed by the fronto-clypeus and the other by the ocelli. Between these projecting parts the head is slightly depressed. The posterior surface of the head (text-fig. 2, A) is almost flat, with the exception of the part of the occiput (*o.*) immediately above the occipital

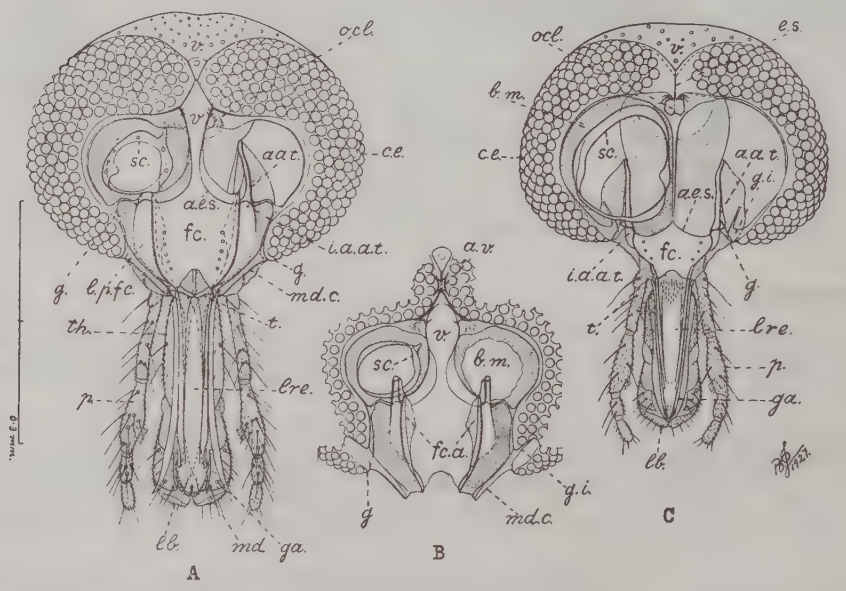

Fig. 1. *Culicoides pulicaris*, L.: A, frontal view of head of ♀; B, inner view of frontal parts of head; C, frontal view of head of ♂.

foramen (*o.f.*). The head of this fly is hypognathous, since it occupies a vertical position with regard to the longitudinal body axis, the mouth-parts being directed downwards. The larger part of the head is formed by a chitinous capsule, the epicranium, which is composed of the following sclerites and regions of the head: the *fronto-clypeus* (*fc.*), *vertex* (*v.*), *genae* (*g.*), *postgenae* (*pg.*) and *occiput* (*o.*).

The *fronto-clypeus* ("clypeus" of systematists) is formed by the fusion of two unpaired sclerites—the front and the clypeus. The fronto-clypeal suture produced by this fusion is absent in the fronto-clypeus of *Culicoides*, though it is present in the closely related family CHIRONOMIDAE in the genera *Chironomus* and *Tanypus*, in which

* According to a later verbal communication by Dr. Dyce Sharp a paper by him now in the press shows that the natural host of *A. perstans* is *Culicoides austeni*, Cart., Ingr. & Macf. and not *C. grahami*.

the structure of the head is essentially the same as in flies of the genus *Culicoides*. The fronto-clypeus is convex in both male and female, its surface being covered with very minute scales and bearing comparatively long setae, which are directed anteriorly. In the female there are five setae to each side, whereas in the male there are only three. The anterior border of the fronto-clypeus is strongly incurved and is connected with the *labrum-epipharynx* (*lre.*) by two very small sclerites, referred to as *tormae* (*t.*) by Peterson (1916). The position of these sclerites is different in the sexes of *Culicoides pulicaris* (text-fig. 5, A, B). In the female they articulate posteriorly with the points produced by the arched anterior border of the fronto-clypeus and with the *lateral parts of the labrum* (*l.pr.*); whereas anteriorly they articulate with the *median part of the labrum* (*m.pr.*). In the male the tormae are attached to the lateral parts of the fronto-clypeus throughout their entire length, and each is connected with the lateral parts of the labrum only. Each of the postero-lateral parts of the fronto-clypeus is fused with the *anterior arm of the tentorium* (*a.a.t.*), the sutures of these fusions being very distinct between the fronto-clypeus and its *lateral parts* (*l.p.fc.*). On the inner surface of the fronto-clypeus the lines of fusion are represented by very prominent apodemes, the *fronto-clypeal apodemes* (*fc.a.*), which serve for the attachment of the muscles of the head. The lateral parts of the fronto-clypeus are more developed in the head of the female than in that of the male, and it is obvious that they have originated from the anterior arms of the tentorium.

The posterior part of the fronto-clypeus is separated from the *vertex* (*v.*) by the *arms of the epicranial suture* (*a.e.s.*). In the head of the male (text-fig. 1, C) the arms of the epicranial suture are represented by the thickened posterior edge of the fronto-clypeus, which extends from the narrow anterior part of the vertex to the *invaginations of the anterior arms of the tentorium* (*i.a.a.t.*). I agree with Peterson (1916) that in the Diptera "the location of the invaginations of the anterior arms of the tentorium usually helps to determine the location of the epicranial suture." In the female, however, there is a marked difference in the structure of the posterior part of the fronto-clypeus, which is completely fused with the anterior part of the vertex, but the dark lines extending from the invaginations of the anterior arms of the tentorium undoubtedly represent the arms of the epicranial suture (text-fig. 1, A).

The *vertex* (*v.*) is a paired region of the head-capsule, and in the generalised insects is divided into two halves by the stem of the epicranial suture, while in the Diptera, in consequence of the great modification of the head-capsule, the stem of the epicranial suture is present in a few Nematocera only, and in most of them it has lost the connection with the arms. In *Culicoides pulicaris* the vertex is situated between the fronto-clypeus and the occiput, occupying part of the frontal and dorsal surfaces of the head. The stem of the epicranial suture (*e.s.*) is present in the male only, and its connection with the arms is lost in the narrow part of the vertex, which lies between the bases of the antennae. This part of the vertex, which is called the "front" by systematists, is very much reduced in consequence of the great development of the first antennal segments, and becomes gradually very narrow and almost membranous towards the anterior end, which is fused with the fronto-clypeus. In the middle of this part of the vertex, just below the stem of the epicranial suture, are situated two *ocelli* (*ocl.*). So far as I know, the ocelli have not been described in the CERATOPOGONIDAE. Their external structure is essentially similar to that of *Tanypus varius* and *T. choreus*. In the total preparation of the head the ocelli are seen as lightly coloured, round or ovoid spots surrounded by very fine streaks of the integument of the vertex. The longitudinal section (Pl. ix, fig. 6) shows that the chitinous integument of the ocellus is transparent and covered with very small bristles. The cellular layer of the anterior part of the ocellus apparently represents the modified corneagen cells. Below this layer there is a cone formed by nerve end-cells, which are loaded with pigment granules and are in direct connection with the fibres of the *ocellar nerve* (*ocl.n.*) arising from the protocerebral lobe. Between the

compound eyes the vertex is smooth and slightly depressed in the middle. The posterior part of the vertex is separated from the anterior part by a very distinct suture arising from the epicranial suture. This suture is formed by the apodeme that surrounds the parts of the posterior borders of the compound eyes, and immediately behind it the vertex bears comparatively long and stout setae directed forwards.

In the female the anterior part of the vertex is much broader than that of the male (text-fig. 1, A). The stem of the epicranial suture is indistinct and the ocelli are separated from each other. They are disposed at the sides of very distinct sutures, which are connected with the arms of the epicranial suture anteriorly and with an X-shaped suture posteriorly. The X-shaped suture is situated between the compound eyes, and its posterior part corresponds to the suture of the vertex of the male that extends along the posterior borders of the compound eyes and separates the anterior

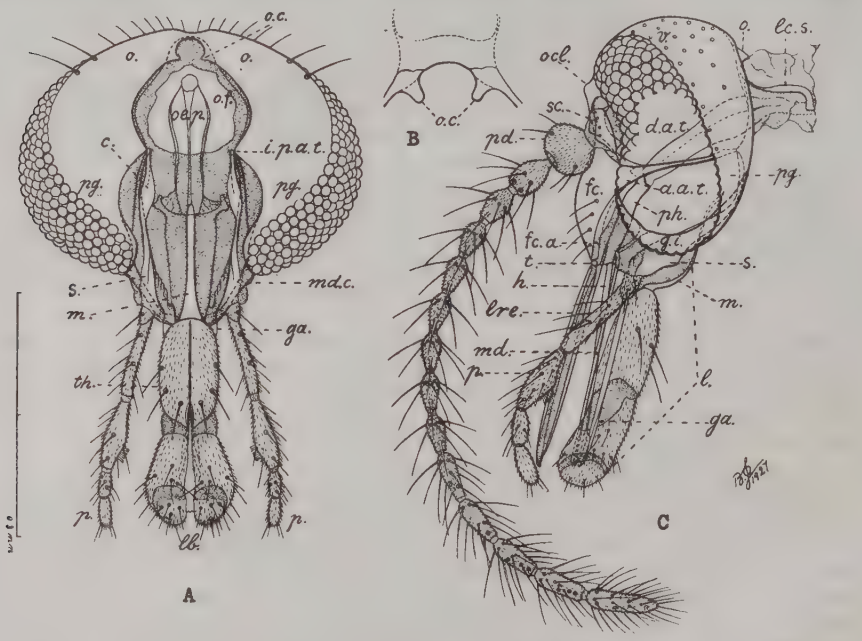

Fig. 2. *Culicoides pulicaris*, L.: A, posterior view of head of ♀; B, dorsal arch of occipital foramen and occipital condyles (*o.c.*); C, lateral view of head.

part from the posterior part of the vertex. These sutures are formed by the *apodemes of the vertex* (*a.v.*). They represent secondary structures and serve for the attachment of the muscles of the head. The arrangement of the apodemes of the vertex inside the head-capsule, as also of the sutures formed by them on the external surface, differs considerably in the species of the genus *Culicoides*. This difference will be noted in text-figs 1, A and 3, A, B. The posterior part of the vertex of the head of the female has practically the same structure as that of the male, but the number of setae is greater in the former sex. The chaetotaxy of the vertex may be very useful in the classification of these flies, since the arrangement of these setae, their size and number are different in the various representatives of the genus. Posteriorly the vertex is continuous with the occiput, and there is no suture separating these regions of the head-capsule.

The *occiput* (*o.*) occupies the upper part of the posterior surface of the head, extending from the vertex to an imaginary transverse line drawn across the head through *occipital condyle* (*o.c.*). The part of the occiput which surrounds the dorsal arch of the *occipital foramen* (*o.f.*) is thickened, projecting posteriorly and slightly overlapping the foramen. The greater part of the posterior surface of the head is occupied by the *postgenae* (*pg.*). Each postgena extends ventrally from the imaginary transverse line to the lower part of the compound eye. They surround the ventral arch of the occipital foramen and the proboscis membrane, being bounded laterally by the compound eyes. Around the occipital foramen the edges of the postgenae are thickened and project into the head-capsule.

The *occipital foramen* (*o.f.*) occupies a median and dorsal position on the posterior surface of the head and is arched dorsally and ventrally. The dorsal arch is narrow and complete, whereas the ventral arch is very broad and is interrupted in its ventral part. At the points where the dorsal and ventral arches meet there are two *occipital condyles* (*o.c.*). Each condyle is attached to the *latero-cervical sclerite* (*lc.s.*), known as the neck or jugular sclerite. The cervical membrane is attached to the thickened edge formed by the occiput and postgenae around the occipital foramen and is continuous with the proboscis membrane, which occupies the median and the lower part of the posterior surface of the head.

The greater part of the lateral surfaces of the head is occupied by the *compound eyes* (*c.e.*). They are kidney-shaped and their ventral part is broader than the dorsal part. The space between the eyes on the vertex varies in different species of these flies. In the male of *Culicoides pulicaris* (text-fig. 1, c) the compound eyes are narrower in the middle, on account of the great development of the first antennal segments, and are slightly displaced laterally in the ventral parts of the head. Consequently the head-capsule of the male is a little broader ventrally and not so round as in the female. The frontal border of the compound eye is surrounded by a narrow chitinous rim, which folds into the head-capsule and is continuous with the gena ventrally. The *genae* (*g.*) are represented by a very narrow chitinous strip surrounding the frontal and the ventral borders of the compound eyes. The border of this strip infolds into the head-capsule, forming a crescent-shaped chitinous plate or the *genal infold* (*g.i.*). From the inner edge of these infolds arise the *mandibular condyles* (*md.c.*), which serve for the articulation of the mandibles. Just below the antennae each gena is connected by a very narrow chitinous rod with the invagination of the anterior arm of the tentorium. On the posterior surface of the head the genae pass into the postgenae. From the fronto-clypeus they are separated by a membrane which spreads from the chitinous rods to the mouth-parts. This membrane is continuous laterally with the membrane of the posterior surface of the head, and its lower part, which forms a membranous cone and connects the mouth-parts, is homologous with the proboscis membrane of the specialised Diptera.

Reference has already been made several times to the tentorium of these flies. This structure will now be described in more detail, since it furnishes the points for the attachment of many muscles of the mouth-parts and some muscles of the antennae and neck. In the generalised insects the tentorium is formed by three pairs of invaginations of the integument of the head. Two pairs occur on the anterior surface of the head, one pair being associated with the lateral parts of the fronto-clypeus and the other with the antennae. The third pair of invaginations is on the posterior surface of the head, being associated with the occipital foramen and the points of attachment of the maxillae. These invaginations form the chitinised rod-like structures inside the head-capsule. The rods produced by the pair of invaginations at the side of the fronto-clypeus are called the *anterior arms of the tentorium*; the ones formed by the invaginations connected with the antennae are the *dorsal arms of the tentorium*; and those formed by the invaginations of the posterior surface of the head, the *posterior arms of the tentorium*. Three pairs of invaginations are present

in two families of the Diptera, viz., the SIMULIIDAE and TABANIDAE, whereas in all other Diptera the two invaginations associated with the antennae are absent and the dorsal arms of the tentorium formed by them greatly reduced or lost (Peterson, 1916). There are only two pairs of invaginations in the genus *Culicoides*, which form two rod-like structures inside the head-capsule, each consisting of the *anterior arm* (*a.a.t.*) and *posterior arm of the tentorium* (*p.a.t.*), which are fused together. The dorsal arms of the tentorium are indistinct, being probably incorporated with the anterior arms. The invaginations of the anterior arms of the tentorium are associated with the postero-lateral parts of the fronto-clypeus immediately below the first antennal segments, and the anterior arms formed by them represent hollow chitinous rods, which are parallel and directed posteriorly (text-fig. 2, C). The posterior parts of the anterior arms are fused with the posterior arms of the tentorium, the lines of fusion being indistinct.

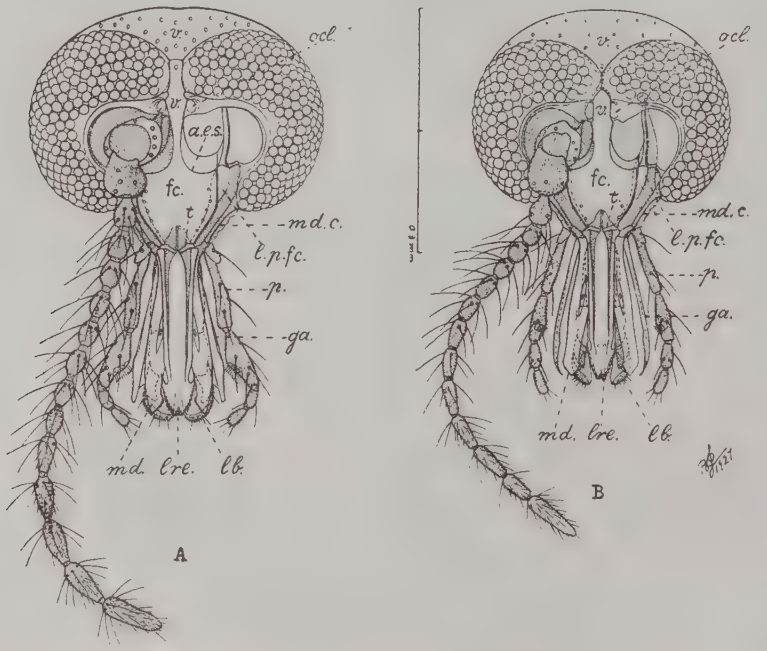

Fig. 3. Frontal view of head of: A, *Culicoides vexans*, Staeg.; B, *C. obsoletus*, Mg.

The invaginations of the posterior arms are associated with the occipital foramen and the cardines of the maxillae (text-fig. 2, A). In *Culicoides* the structure of the tentorium and its position inside the head-capsule is essentially the same as in the genus *Tanypus*.

The Antennae.

The antennae are composed of fifteen segments in both sexes; in the male they are distinctly plumose (text-fig. 4, A). The *scape* (*sc.*), or the first segment of the antennae, is ring-shaped, strongly chitinised and brown in colour. At the posterior border of this segment there is a very distinct process, which protrudes into the head-capsule and serves for the attachment of the muscles of the second antennal segment. Externally the scape bears a few setae and is attached by the *basantennal membrane*

(*b.m.*) to the periphery of the *basantenna*, which in these flies is formed by the following parts of the head : the chitinous rim of the border of the compound eye, the lateral infolded parts of the vertex, and the chitinous rod of the gena. In the antennae of the male the scape is nearly twice as large as that of the female and is devoid of the process at the posterior border. The *pedicle* (*pd.*), or the second segment of the antenna, is almost globular and dark in colour. Its surface is covered with scales and bears a few setae directed forwards. The anterior part of this segment has a funnel-shaped depression, which is formed by a very thin membrane. At the lower part of this depression there is a chitinous ring to which the first segment of the flagellum is attached. In the male the pedicle is more than twice the size of that of the female. In both sexes is exhibits a very peculiar internal structure, which is better developed in the pedicle of the male and belongs to the auditory apparatus or Johnston's organ. I do not intend to discuss the anatomical details of this organ, since it was described in a *Culex* mosquito by Johnston (1855), in *Chironomus* by Miall & Hammond (1900), and quite recently by Christophers, Shortt & Barraud (1926) in *Phlebotomus argentipes*. It is also present in the pedicle of the antennae of *Calliphora erythrocephala*, *Musca*

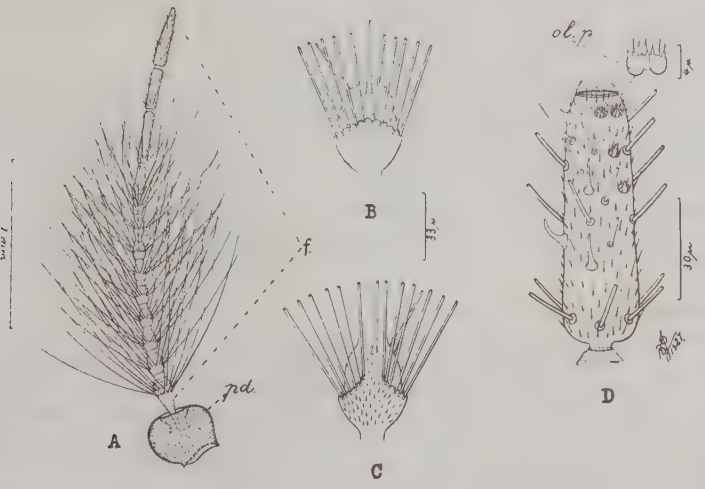

Fig. 4. *Culicoides pulicaris*, L. : A, antenna of ♂, first segment not shown ; B, second segment of flagellum of antenna of ♂ ; C, same, viewed from the opposite side ; D, fourteenth segment of antenna of ♀.

domestica and the pupiparous fly *Lynchia maura*, though in all these flies its structure is greatly simplified. The presence of Johnston's organ in flies belonging to different suborders indicates that the pedicle of the generalised Diptera is homologous with the same segment of the more specialised Diptera.

The remaining segments of the antennae comprise the *flagellum* (*f.*). The first segment of the flagellum is nearly oval, its anterior part being broad, whereas the posterior part is elongated into a narrow process that is inserted into the funnel-shaped depression of the pedicle. The succeeding segments of the flagellum are slightly elongated, each of them decreasing in size towards the eighth segment, which is the smallest, the remaining five segments being much elongated and almost cylindrical. All the segments of the flagellum are covered with scales and bear long setae, which have distinct thecae at the base. On the first eight segments the setae are arranged in complete whorls. In addition to the setae all the segments, with the

exception of the first, have a very long seta-like scale in their anterior part. On the five elongated segments of the flagellum the setae are shorter and do not form complete whorls. A few curved scales are scattered over the surface of the segments. Small pits, the *olfactory pits* (*ol.p.*), are present on the first and on the five elongated segments of the flagellum. Each pit is bordered by scales and has a very minute *olfactory sensilla*, which is hardly visible on account of its transparency. In the flagellum of the male the first segment is of the same form as that of the female, the succeeding eight segments being ovoid and the last four much elongated. The setae of the ten segments of the flagellum are very long; their thecae are fused together and form a very distinct festooned line round the middle part of each segment (text-fig. 4, B, C), which is interrupted on that side of the segment that is covered with scales. Two setiform scales are present at the anterior part of each ovoid segment. The setae of the three terminal segments of the flagellum are very short and do not form distinct whorls. There is a small number of olfactory pits on the elongated terminal segments only.

The Mouth-parts. General Account.

The mouth-parts and the sucking apparatus of the genus *Culicoides* are composed of the same parts as those of the following genera of the blood-sucking Nematocera, viz., *Phlebotomus*, *Simulium*, *Culex* and *Anopheles*.

The biting apparatus consists of the labrum-epipharynx, the mandibles, the maxillae, the labium and the hypopharynx. Of these the labrum, the epipharynx and the hypopharynx are not true appendages. The labrum forms part of the segment which enters into the composition of the head-capsule, whereas the hypopharynx and the epipharynx are outgrowths of the mouth.

The sucking apparatus is formed by the pharynx and the oesophageal pump. All the above-mentioned parts are also present in the male of *Culicoides pulicaris*, though it will be shown later that their structure is not adapted for the sucking of blood.

The Labrum-epipharynx (text-fig. 5).

In the Diptera this mouth-part is formed by the fusion of the labrum and the epipharynx. The labrum-epipharynx of *Culicodes pulicaris* is somewhat arrow-shaped and armed with six terminal and fourteen lateral teeth. The labrum, as in all the other blood-sucking Nematocera is composed of three parts: one median and two lateral, which represent the chitinizations of the labrum and were described in detail for the first time by Christophers, Shortt & Barraud (1926) in *Phlebotomus argentipes*, Ann. & Brun.

The *median part of the labrum* (*m.pr.*) is guttered dorsally and is movably attached to the tormae by its posterior end. Towards the anterior part of the labrum-epipharynx the median part gradually becomes broader and slightly overlaps the lateral parts of the labrum. From the posterior end of this part arises a very long process, the *posterior process of the labrum* (*p.p.lr.*) which serves for the attachment of the elevator and the depressor muscles of the labrum-epipharynx. Immediately behind the anterior border of the median part there are present two rod-like sensillae situated at the sides of a darkly pigmented and elongated spot.

The *lateral parts of the labrum* (*l.pr.*) are rod-shaped and are attached basally to the antero-lateral parts of the pharynx, each being articulated by a very short process to the posterior part of the torma (text-fig. 7, A). The anterior edge of each lateral part is armed with seven very strong teeth, which represent the *lateral teeth of the labrum-epipharynx* (*l.th.*) and are directed forwards. Posteriorly the armed edge ends in the long tooth-like spine, which is very weakly chitinized and is directed backwards (text-fig. 5, C). In transverse sections of the labrum each lateral part is hook-shaped (Pl. xi, figs. 14–19); its dorsal border is much thicker than the ventral one and is

loosely connected with the median part by a very thin membrane, which invaginates into the cavity formed by the labrum and the epipharynx. Posteriorly this membrane is attached to the tormae, from which it spreads to the fused anterior ends of the parts composing the labrum.

The *epipharynx* (*e.*) arises from the antero-dorsal part of the pharynx and is almost membranous in this place (Pl. xi, fig. 20). It is guttered dorsally, occupying the median position between the lateral parts of the labrum, with which it is basally connected by its membranous lateral borders. However, in the extreme anterior part of the labrum-epipharynx, the epipharynx is fused with the lateral and dorsal parts of the labrum. The site of the fusion of the epipharynx with the lateral parts is shown by

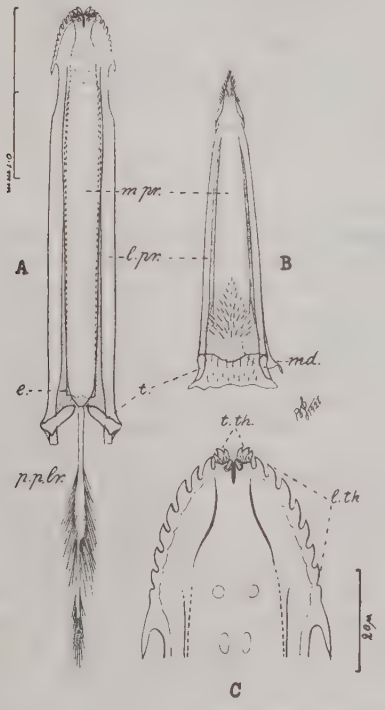

Fig. 5. *Culicoides pulicaris*, L.: A, labrum-epipharynx of ♀; B, same of ♂; C, tip of labrum-epipharynx of ♀ highly magnified.

two dark lines in text-fig. 5, c. On the inner surface of the epipharynx there is an apodematous process which is attached dorsally to the median part of the labrum. In the cleared preparation this process is seen as a darkly pigmented, elongated spot at the anterior edge of the labrum-epipharynx. The anterior edge of the epipharynx is divided by a very small median notch into two halves, each having an almost rounded apex, which is armed with three very strong teeth. These represent the *terminal teeth of the labrum-epipharynx* (*t.th.*) and are surrounded at the base by small tooth-like rods. The direction of the sharp points of these teeth is different in various specimens of *Culicoides pulicaris*. This apparently depends upon the protraction and retraction of the median part of the labrum with regard to the lateral parts and the epipharynx.

There are present four very minute sensillae on the ventral surface of the epipharynx, which are seen in transverse sections only, whereas in the toto-preparations they appear as light spots in the middle of the narrow part of the labrum-epipharynx.

The labrum-epipharynx of the male is one-third shorter than that of the female. The labrum is composed of three parts. The basal portion of the median part is membranous, bearing a triangular patch of spines, and is immovably attached to the anterior border of the fronto-clypeus. Laterally it is connected by the membrane with the lateral parts, as in the female, and is fused with them not far from the anterior end. The anterior part of the labrum-epipharynx is almost entirely membranous; its apex is very flexible and bears thin bristles. On the membrane of the anterior part there are present two rod-like sensillae and two very small protuberances. The epipharynx occupies the same position as that of the female and bears two sensillae on the ventral surface in its anterior part. The structure of the labrum-epipharynx of the male of *Culicoides pulicaris* has more in common with that of the female *Tanypus varius* and *T. choreus* than with the female of its own species. The greatly developed membranous part of the labrum-epipharynx shows that this mouth-part is not adapted for blood-sucking.

The Mandibles (text-fig. 6).

Each mandible represents a blade, the dorsal surface of which is strongly chitinized, whereas the ventral surface is almost entirely membranous. The middle part of the mandible is slightly broader than the anterior and the posterior parts, which are bent in opposite directions with regard to each other. The anterior part is bent inwards, *i.e.*, towards the other mandible, forming at the apex a short and slightly rounded saw-like margin. In the mandibles of *Culicoides pulicaris* and *C. obsoletus* the hind-most tooth of the margin is the smallest, whereas the apical one is the largest. In *C. vexans* all the teeth are of almost equal size. The posterior part of the mandible is strongly bent outwards; its base is very thick and has two processes by which the mandible articulates with the mandibular condyle (text-fig. 6, E). One of these processes is somewhat hook-shaped. It occupies a dorsal position at the base of the mandible and is inserted into the round socket of the condyle. Ventrally this process is fused with the flat surface of the second process, to which the *tendon of the abductor muscle of the mandible* (*tn.ab.md.*) is attached. During the abduction and adduction of the mandible the ventral process moves along the flat surface of the depression on the ventral surface of the condyle. The dislocation of the mandibular joint is prevented by the hook-shaped process, which is interlocked with the side of the socket.

The inner edge of the mandible is much thinner than the outer and is membranous in the posterior third, where it gives off a very long *tendon of the adductor muscle of the mandible* (*tn.ad.md.*). In addition to the two long tendons, there is a third which belongs to the *accessory adductor muscle of the mandible* (*tn.a.ad.md.*). This is attached to the dorsal surface of the narrow basal part of the mandible. In the middle part of each mandible there is a very interesting structure, which is seen in cleared specimens as a median depression (*d.*) outlined in the form of a spindle with a darkly pigmented round or ovoid body in the middle or slightly at the side. So far as I know, the structure and functions of the depression and the associated part have never been correctly understood, and since they are directly related to the position of the mandibles in relation to the other mouth-parts, it will be best if they are considered together with the latter. When the mouth-parts are at rest, the mandibles are closed like scissors, and their saw-like edges slightly project beyond the antero-lateral portions of the labrum-epipharynx, below the lateral teeth (text-fig. 1, A). In transverse sections of the mouth-parts (Pl. xi, figs. 14–19) it is seen that the mandibles occupy the space between the labrum-epipharynx and the hypopharynx. The left mandible always lies above the right, which is tightly applied to the hypopharynx. As the

anterior part of the mandibles is bent inwards, the saw-like edge of the right mandible is on the left and that of the left mandible on the right side of the labrum-epipharynx.

The above-described disposition of the mandibles is maintained by the conformation of their middle parts in the following manner. The dorsal surface of each mandible has a median depression outlined in the form of a spindle, as already mentioned, and under this depression, but on the ventral surface, there is a strongly chitinized process (Pl. x, fig. 11, Pl. xi, fig. 18), which in the left mandible is slightly broadened ventrally and is interlocked with the depression on the dorsal surface of the right mandible. The process of the latter is much narrower than that of the left mandible and is interlocked with the lumen of the salivary duct of the hypopharynx. In some transverse sections of the mouth-parts the mandibles and the hypopharynx fit each other so tightly that there is no space left between their adjacent parts.

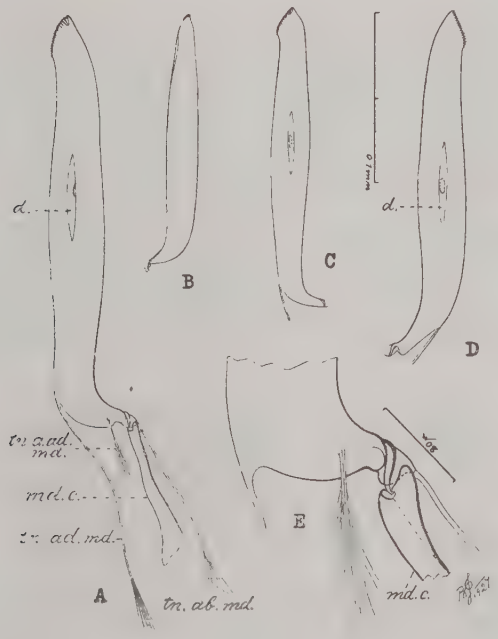

Fig. 6. Mandibles of: A, *Culicoides pulicaris*, L., ♀; B, *C. pulicaris* ♂; C, *C. obsoletus*, Mg., ♀; D, *C. vexans*, Staeg., ♀; E, base of mandible of *C. pulicaris*, showing articulation with mandibular condyle (*md.c.*).

The relation of the base of the mandible to the adjacent parts and to the membrane in the region of the mouth is as follows: The lateral borders of the labrum and the hypopharynx are connected by a membrane that extends anteriorly and is attached to the base of the mandible, which separates it into two parts. One part of the membrane connects the lateral part of the labrum with the dorsal surface of the mandible, and the other the ventral surface of the mandible with the hypopharynx (Pl. xi, fig. 20). A little further on, the lines of attachment of the membrane to the surfaces of the mandible extend obliquely and anteriorly to its outer edge. Here the two parts of the membrane meet and are continuous with the membranous cone of the head-capsule.

If the position of the mandibles of the genus *Culicoides* is compared with those of the genera *Phlebotomus* (Pl. x, fig. 12) and *Simulium* (Pl. x, fig. 13), it will be seen to be similar. The mandibles of *Simulium* are strongly guttered ventrally, their ventral surfaces being membranous and devoid of the processes. In *Phlebotomus* they are also guttered in the middle, and there is a trace of the process on the membranous ventral surface of the right mandible, which occupies a dorsal position with regard to the left one. The trace of the process is also seen in the total preparation of the right mandible as a brown-coloured spot.

The male of *Culicoides pulicaris* has but very weak mandibles. Each of them bears five spine-like teeth on the apex, which are very small and almost hyaline. The mandibles occupy the same position as in the female, but are devoid of the depression and the process on the surface of their middle parts.

The Maxillae (text-fig. 7).

The maxilla of the blood-sucking Nematocera and Brachycera is composed of the following parts: the cardo, the stipes, the galea and the maxillary palp. The *lacinia* has only been described in *Tabanus* by Patton & Cragg (1913) and in *Simulium* by Peterson (1916). The latter author was, however, not quite sure about the homology of this part in the Diptera. Recently the maxillae have been studied through the various orders of insects by Crampton (1923*a*), who says that the part described in *Tabanus* as the lacinia is apparently homologous with the *interlora* of the Hymenoptera.

The *cardo* (*c.*) of the maxilla of *Culicoides pulicaris* has the shape of a boat-paddle, its rod-like posterior part being very thick and connected with the invaginations of the posterior arm of the tentorium. Anteriorly the cardo is fused with the stipes. The *stipes* (*s.*) is represented by a broad and slightly convex plate, the inner lateral margin of which is strongly chitinized and fused with the *posterior process of the galea* (*p.p.ga.*). The anterior part of the stipes is almost membranous and bears the maxillary palp.

The *galea* is represented by a maxillary blade, which is deeply guttered and twisted on its own axis in the anterior part. It is seen in transverse sections that only the outer surface of the galea is chitinized, whereas the inner surface is membranous. At its apex the outer edge of the galea is armed with twenty triangular teeth which are directed backwards. Towards the base the galea becomes gradually broader and more chitinized. It gives off a very strong process, the posterior process of the galea, which serves for the attachment of the retractors of the maxillae.

The *maxillary palp* (*p.*) consists of five segments. The first is very small and somewhat cone-shaped, only its outer surface being chitinized, whereas the surface facing the galea is membranous and serves for the attachment of the second segment. The second segment is the largest one in the palp and is rod-shaped, being connected by a distinct membranous joint with the third segment, which is unilaterally dilated in the middle. This dilatation carries a bunch of spatulated sensillae (text-fig. 7, c) arising from the bottom of small pits which are present on the anterior surface of the dilatation at the apex. The sensillae are connected with the palpal nerve *via* nerve cells which occupy the cavity of the dilated part of the segment. The fourth and fifth segments of the palp are short. The surfaces of each segment are covered with spines and bear moderately long setae.

The position of the maxilla with regard to the other parts of the head-capsule is shown in the text-fig. 2, A. The cardo and the stipes occupy a lateral position in the membrane of the posterior surface of the head. This membrane surrounds them at the sides and is attached to their lateral borders, extending laterally to the postgena and mesially to the cardo of the other maxilla and to the mentum of the labium. The ventral part of the membrane is attached to the posterior part of the theca and is

continuous with the membrane which connects the labrum-epipharynx with the mandible. The position of the galea is seen better in transverse sections of the mouth-parts (Pl. x, fig. 11 ; Pl. xi, figs. 14–19). When these are at rest, the posterior and the middle part of the galea lie at the sides of the labrum-epipharynx and the hypopharynx in

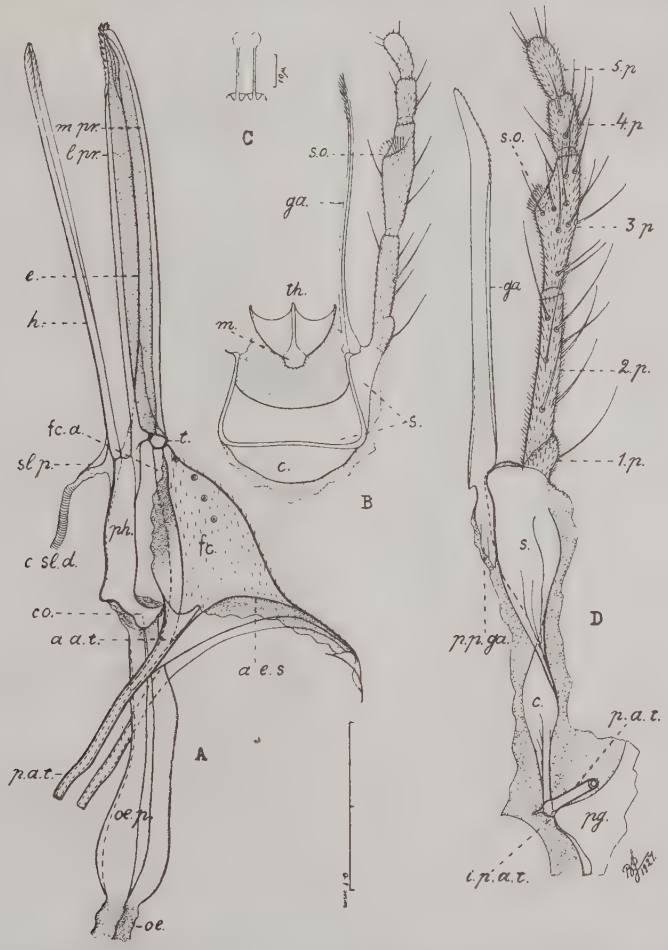

Fig. 7. *Culicoides pulicaris*, L. : A, lateral view of fronto-clypeus (*fc.*), labrum-epipharynx, hypopharynx (*h.*), pharynx (*ph.*), and oesophageal pump (*oe.p.*) ; B, maxilla of ♂ ; C, sensilla of sense-organ of third segment of maxillary palp ; D, maxilla of ♀, showing connection of cardo (*c.*) with invagination of posterior arm of tentorium (*i.p.a.t.*).

the gutter of the theca. Since the anterior part of the galea is twisted, it lies beneath the hypopharynx in the second segment of the labellum and occupies the most ventral position in relation to the other mouth-parts.

The maxilla of the male (text-fig. 7, B) differs very much in structure from that of the female. The cardo and the stipes are fused mesially with the same parts of the

other maxilla, forming together a broad plate, which occupies the median position in the membrane of the posterior surface of the head. The galea is slightly chitinized and is one-fourth shorter than that of the female. It bears a row of flexible bristles, which arise from the apical part of the outer margin and apparently represent the greatly modified teeth. The palp is also reduced in length, and its segments bear very few setae.

The Labium (text-fig. 8).

The labium of the Diptera is formed by the mentum, the theca and the two-segmented labella. The mentum is present in a few generalised Diptera only, whereas the theca and the labella exhibit considerable variation in their structure throughout

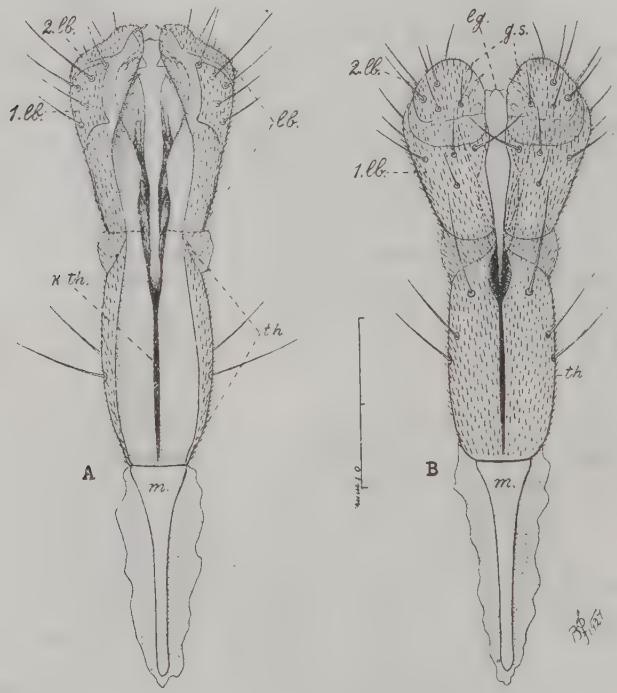

Fig. 8. *Culicoides pulicaris*, L. : A, dorsal view of labium of ♀ ; B, ventral view of same.

the order. The homology of the parts forming the labium is incorrectly described in many papers on the mouth-parts of the Diptera. Thus, the theca was homologized with the mentum, the labella with the paraglossae, and the structure attached to the posterior end of the theca was spoken of as the submentum. In 1913 Frey regarded the labella as the modified labial palps, and in his succeeding paper (1921) he pointed out that Burmeister (1832), Erichson (1840), Becher (1882), Kraepelin (1884) and Grünberg (1907) supported this view. MacGillivray (1924) criticised the same view expressed by Crampton (1921 and 1923*b*), who in his important paper on the labium of holometabolous insects (1925) has shown quite convincingly that the labella represent the modified labial palps, the theca is formed by the fusion of the palpigers, and that the structure attached to the posterior end of the theca is the mentum.

The *mentum* (*m.*) of the labium of *Culicoides pulicaris* is a chitinized rod extending from the theca along the middle of the posterior surface of the head (text-fig. 2, A). In text-fig. 2, C it is seen that the mentum is bow-shaped when viewed laterally. Its narrow posterior part is thin, whereas the broad anterior part is very thick and attached to the posterior part of the theca.

The *theca* (*th.*) forms the largest part of the labium. It represents the thick-walled chitinous gutter, which is slightly broader in the middle. The surface of the theca is covered with very small spines and bears four lateral and two antero-ventral setae, which are long and directed anteriorly. The structure of this part is better understood in transverse sections of the labium (Pl. xi, figs. 17–19). The ventral surface of the theca is grooved in the middle along its entire length. Immediately above this groove, on the inner surface, arises a parademe, or the *keel of the theca* (*k.th.*), which is formed by the fusion of the greatly reduced inner walls of the palpigers. Anteriorly, the groove becomes deeper and the keel gradually disappears. The edges of the lateral parts of the theca bend inwards and are connected by the membrane, which forms a very deep gutter in which the other mouth-parts are concealed when at rest.

The *labella* (*lb.*) consist of two segments (text-fig. 8, A, B) which represent the modified two-segmented labial palp. The first segments of the palps are much longer than the second, being fused together at the base and attached by the membrane to the anterior end of the theca. The short second segments of the palps are attached to the anterior ends of the first segments. There is a very broad space between these segments occupied by the *ligula* (*lg.*) and the other mouth-parts when the latter are at rest (Pl. xi, fig. 14). In the anterior part of the inner surface of the second segment there are present four *gustatory sensillae* (*g.s.*) connected by nerve fibres with the sensory cells, which are attached to the ramifications of the labial nerve (Pl. ix, fig. 3). The surface of the segments of the labella is covered with spines and bears long setae directed forwards.

The relative position of the parts forming the labella and their origin at the base of the theca is better seen in transverse sections of the labium. If the section through the apex of the theca (Pl. xi, fig. 18) is compared with that through the base of the labella (Pl. xi, fig. 17), it will be seen that the ventral surfaces of both parts are grooved and their walls are continuous. This is due to the fact that the modification undergone by the first segments of the labial palps, which form the first segments of the labella, conforms with the modification of the palpigers which have given rise to the theca. This is, however, only true for the base of the first segment of the labial palps, since anteriorly they become separated from each other by the ligula (Pl. xi, fig. 15), which arises as a chitinous band from the anterior end of the fused inner walls of the palpigers. In the basal part of the first segment of the labella the ligula is attached laterally to the first segments of the labial palps and evaginates between their inner walls ventrally (Pl. xi, figs. 16 and 17). A little further, the lateral parts of the ligula fuse with the membrane which connects the inner walls of the first segments of the palps and becomes distinct as a separate organ extending anteriorly between the second segments of the labial palps (Pl. xi, fig. 14). The inner membranous surface of these segments is gathered into very deep folds, which straighten out during the eversion of the labella.

The labium of the male is much shorter than that of the female. The theca and the labella have the same structure, whereas the mentum (*m.*) is represented by a very small vestige attached to the posterior part of the theca (text-fig. 7, B).

The Hypopharynx (text-fig. 9).

The hypopharynx represents a chitinous piece which arises from the floor of the pharynx. It is slightly guttered ventrally and is equal in length to the labrum-epipharynx. At the base the hypopharynx is thick and broad, but towards the

middle it becomes slightly narrower and again increases in breadth near the anterior end. The apex of this organ is strongly chitinized and ends in very strong teeth directed forwards. The number of the teeth and their form differ very much in the various species of the genus *Culicoides*. The posterior third of the hypopharynx is perforated by the *salivary duct* (*sl.d.*), which opens on the dorsal surface of the organ. Through the remaining two-thirds of the hypopharynx the duct extends as a long groove towards the extremity.

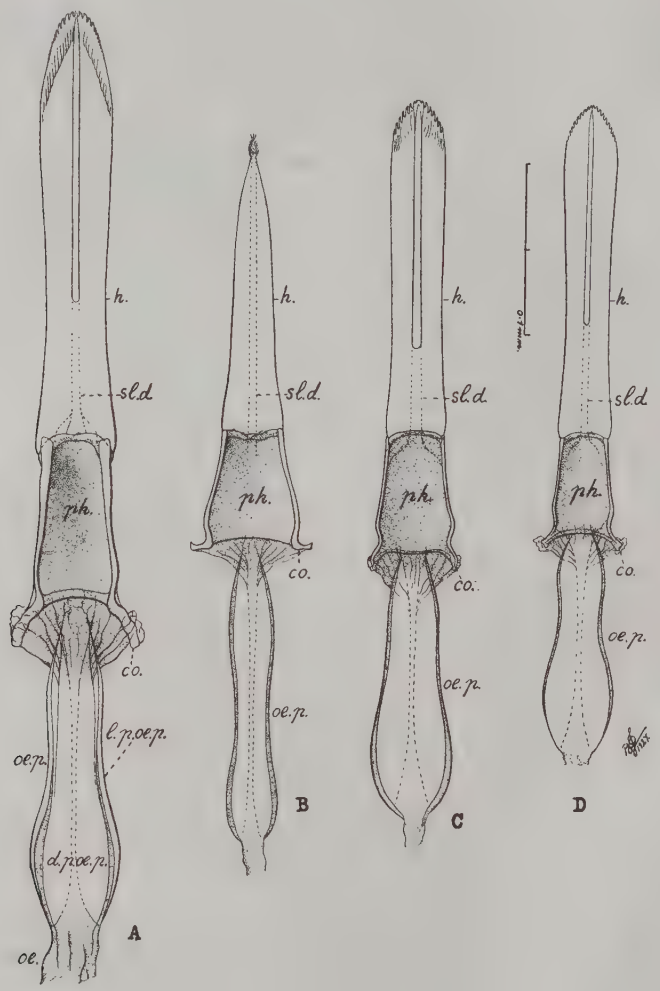

Fig. 9. Hypopharynx (*h.*), pharynx (*ph.*) and oesophageal pump (*oe.p.*) of: A, *Culicoides pulicaris*, L., ♀; B, same, ♂; C, *C. vexans*, Staeg., ♀; D, *C. obsoletus*, Mg., ♀.

The relative position of the hypopharynx to the mandibles and the maxillae has already been discussed in connection with the description of these parts, and its relation to the labium is as follows. The posterior part of the hypopharynx lies in

the gutter of the theca, occupying the most ventral position with regard to the other mouth-parts, whereas in the second segment of the labella it lies above the maxillae and below the mandibles (Pl. xi, fig. 14). The latter structures are a little shorter than the hypopharynx and keep their apices apart, therefore the apices of the hypopharynx and the labrum-epipharynx are almost in contact. It is seen in figs. 14–20, Pl. xi, that the lateral borders of the hypopharynx are connected with each other by a membrane, which extends along the ventral surface of the hypopharynx to its apex, where it is completely fused with the latter. At the base of the hypopharynx this membrane is attached to the posterior part of the theca and is continuous with the membrane that closes the gaps at the base of the mouth-parts.

The hypopharynx of the male (text-fig. 9, B), is about one-third shorter than that of the female. From the base it gradually becomes narrower towards the apex, which is very flexible and bears very minute bristles.

The Pharynx and the Oesophageal Pump (text-figs. 7, 9).

Before proceeding to the description of these parts it will be necessary to point out that in the different works dealing with the mouth-parts of the Diptera the terminology of the structures in question is not accurate. The mistakes were due to the facts that the authors either restricted themselves to the study of one or few species, or were not acquainted with the work of Peterson (1916). This author has shown that in the Orthorrhapha the basi-pharynx (=pharynx, in the present paper) is connected with the epipharynx and the hypopharynx, whereas in some Athericera and the Acalyptratae and in all the Calyptratae (except in the Oestridae) it is separated from the epipharynx and the hypopharynx by the development of a special piece called the *hyoid*. Some authors termed this piece the "buccal cavity" and homologized it with the pharynx of the Orthorrhapha, whereas the chitinized anterior part of the oesophagus they called the pharynx. The chitinous anterior part of the oesophagus was named by Peterson (1916) the oesophageal pump, and it was shown by him that in the Orthorrhapha the structure of the pump exhibits considerable modifications. In the Cyclorrhapha the pump is absent, and the anterior part of the oesophagus is represented by the membranous tube.

The *pharynx* (*ph.*) of *Culicoides pulicaris* occupies a median and nearly vertical position in the head-capsule, extending from the base of the epipharynx and the hypopharynx upwards (text-fig. 2, C). It is seen in the transverse section of the head (Pl. x, figs. 7 and 8, Pl. xi, fig. 21) that the pharynx is a broad tube, of which the membranous dorsal wall is invaginated into the lumen, whereas the lateral and the ventral walls form a thick-walled gutter. The chitinous wall of this gutter consists of two layers, the outer being membranous and the inner strongly chitinized. Both layers are continuous with the dorsal membranous wall of the pharynx, though the chitinous layer is extremely thin in this place. At the posterior end of the pharynx its dorso-lateral parts are modified into two very strong projections or *cornua* (*co.*), which extend dorsally and serve for the attachment of the protractor and the retractor muscles of the pharynx.

The anterior part of the oesophagus is membranous; its dorsal wall is connected with the membranous dorsal wall of the pharynx, the lateral walls are attached to the cornua and the ventral walls to the posterior edge of the guttered part of the pharynx. Immediately behind this part the oesophagus is modified into the pumping organ, which is called the *oesophageal pump* (*oe.p.*).

The oesophageal pump is shaped somewhat like a spear-head (text-fig. 9, A–D), being constricted in the middle and much broader at the posterior than at the anterior end. The structure of the pump is very difficult to understand in the total preparation, since the parts forming this organ obscure each other. In transverse sections (Pl. x, figs. 9 and 10) it has a triangular shape, being composed of three plates, one *dorsal*

(*d.p.oe.p.*) and two *lateral* ones (*l.p.oe.p.*). Each plate is thickened in the middle and is concave towards the longitudinal axis of the pump. The lateral parts of the plates are very thin and membranous ; their margins bend outwards and are connected with the margins of the other plates by thick chitinous bands which are E-shaped in transverse section. To each plate of the pump are attached the powerful muscles that dilate the organ during their contraction. The oesophageal pump lies in the canal of the brain between the *supraoesophageal* (*sp.g.*) and *suboesophageal* (*sb.g.*) ganglions. Its anterior end is surrounded laterally by *roots of the frontal ganglion* (*r.f.g.*) arising from the tritocerebrum (*tr.c.*). The frontal ganglion lies immediately above the anterior end of the pump and gives off a *recurrent nerve* (*r.n.*) which extends along the middle of the dorsal plate of the pump towards the fore-intestine. The posterior end of the oesophageal pump extends into the neck, where immediately behind the occipital foramen it becomes modified into the thin-walled *oesophagus* (*oe.*), which passes through the neck towards the mid-gut.

In the male (text-fig. 9, B) the pharynx is about one-third shorter than in the female. It is very broad at the posterior end and has its cornua directed laterally. The oesophageal pump has practically the same form and length as that of the female, though its plates are much narrower and weakly chitinized.

The pump is well developed in all the blood-sucking Orthorrhapha and is present in the non-blood-sucking Nematocera and in some Brachycera. It is absent in all the Cyclorrhapha, in which the pumping action is brought about by the pharynx alone.

The Salivary Pump.

From the salivary glands situated in the anterior part of the thorax arise two salivary ducts, which in the posterior part of the head unite into the *common salivary duct* (*c.sl.d.*), and this passes under the suboesophageal ganglion to the *salivary pump* (*sl.p.*). The latter represents the dilated part of the common salivary duct fused with the ventral part of the base of the hypopharynx. In the longitudinal section of the pump (Pl. ix, fig. 4) it is seen that its concave ventral part is chitinized and continuous anteriorly with the ventral surface of the hypopharynx, whereas the dorsal part is thick and membranous and is continuous with the dorsal part of the hypopharyngeal portion of the salivary duct. The salivary pump is crescent-shaped in transverse section and is essentially of the same shape as the pharynx, which is situated immediately above it (Pl. xi, fig. 21). To the middle of the membranous part of the pump are attached the pumping muscles. During the contraction of these muscles the membranous portion of the pump becomes convex, the resulting negative pressure drawing the saliva into the lumen of the pump. After the relaxation of the muscles the membrane invaginates into the lumen of the pump, pushing the saliva through the hypopharyngeal part of the salivary duct. There is a membranous fold at each end of the pump. They project into the lumen and probably act as valves preventing the backward movement of the saliva during the pumping action.

The salivary pump is well developed in all the blood-sucking Nematocera, though in the SIMULIIDAE and the CULICIDAE it differs in structure from that of *Culicoides*. It has been shown by Cornwall (1923) that the presence of the salivary pump in an insect is connected with rapid feeding. *Culicoides pulicaris*, *C. obsoletus* and *C. vexans* take about three minutes to gorge themselves with blood. Being very rapid feeders they have very well developed salivary pumps, which produce forcible ejection of the salivary gland secretion into the puncture.

The Muscles.

The Muscles of the Head (Pls. ix, x, xi).

The mouth-parts are brought into action by twenty-four different muscles. In addition to these there are the muscles of the antennae and the neck. Since the last two sets of the muscles can easily be confused with those of the mouth-parts, a description of them will also be given.

The Muscles of the Neck.

Of these muscles only the *depressors of the head* (*dp.h.*) are located in the head-capsule. These muscles are very long and narrow. They arise in the prothorax and extend through the lateral part of the neck into the posterior parts of the fronto-clypeal apodeme.

The Muscles of the Antenna.

Abductor of the scape (*ab.sc.*). This is a comparatively small muscle arising from the middle part of the anterior arm of the tentorium and attached to the lower outer edge of the anterior part of the scape.

Adductor of the scape (*ad.sc.*). This muscle is almost of the same size as the abductor. It arises from the anterior part of the anterior arm of the tentorium and is attached to the lower inner edge of the anterior part of the scape.

Accessory adductor of the scape (*a.ad.sc.*). This small muscle arises from the apodeme of the vertex and is inserted into the inner lower edge of the posterior part of the scape.

Depressor of the pedicle (*dp.pd.*). A comparatively small band situated in the scape. It arises from the process of the posterior border of the scape and is inserted into the lower edge of the anterior part of the pedicle.

Rotators of the pedicle (*rot.pd.*). A fan-shaped band of muscles arising at the lower edge of the inner surfaces of the scape and inserted into the lower edge of the pedicle.

The Muscles of the Labrum-epipharynx.

Depressor of the labrum-epipharynx (*dp.lre.*). This muscle is composed of two bands arising from the postero-ventral part of the posterior process of the labrum and is attached to the middle of the posterior part of the epipharynx.

Elevator of the labrum-epipharynx (*e.lre.*). This muscle corresponds to the elevator muscle of the labrum in *Phlebotomus* (Christophers, Shortt & Barraud, 1926). It is composed of several bands that arise from the apodemes of the vertex and the middle of the posterior part of the fronto-clypeus. The bands extend obliquely and anteriorly, and are attached to the hyaline tendons of the posterior process of the labrum. The position of the bands with regard to the posterior process of the labrum shows that this muscle is not only the elevator, but the retractor as well.

The Muscles of the Pharynx and the Oesophageal Pump.

Protractors of the pharynx (*pr.ph.*). They correspond to the protractor muscles of the buccal cavity in *Phlebotomus*. Each muscle represents a stout band arising from the posterior part of the fronto-clypeal apodeme and is inserted into the cornu of the pharynx (Pl. x, fig. 8).

Retractors of the pharynx (*r.ph.*). These correspond to the elevator muscles of the buccal cavity in *Phlebotomus*. Each muscle represents a comparatively strong band arising from the lateral part of the apodeme of the vertex, and is inserted into the apex of the cornu of the pharynx.

As the pharynx is fused anteriorly with the lateral parts of the labrum, the action of the protractors and the retractors of the pharynx co-operates with the action of the elevator and the depressor of the labrum-epipharynx. The protraction and retraction of the hypopharynx also depend upon the action of these muscles, since the base of this mouth-part is fused with the floor of the pharynx.

Dilators of the pharynx (*d.ph.*). They correspond to the dilator muscles of the buccal cavity in *Phlebotomus*. Each of these muscles consists of six bands, which arise from the lateral part of the fronto-clypeus and are inserted into the membranous dorsal wall of the pharynx (Pl. x, fig. 7, Pl. xi, fig. 21).

Anterior dorsal dilators of the oesophageal pump (*a.d.d.*). These muscles correspond to the anterior dilator muscles of the pharynx in *Phlebotomus* (Christophers, Shortt & Barraud, 1926) and the anterior dilators in *Anopheles* (Nuttall & Shipley, 1903). Each muscle is composed of three bands, which arise from the apodeme of the vertex and are attached to the anterior part of the dorsal plate of the pump (Pl. x, fig. 9).

Posterior dorsal dilators of the oesophageal pump (*p.d.d.*). These correspond to the dorsal dilator muscles of the pharynx in *Phlebotomus* and the posterior dorsal dilators in *Anopheles*. Each muscle consists of one strong band arising from the thickened part of the occiput and passing under the supraoesophageal ganglion to be inserted into the posterior part of the dorsal plate of the oesophageal pump (Pl. x, fig. 10).

Posterior lateral dilators of the oesophageal pump (*p.l.d.*). These correspond to the lateral dilator muscles of the pharynx in *Phlebotomus* and the latero-ventral dilators in *Anopheles*. Each of these muscles is composed of two bands, which arise from the thickened edge of the postgena at the occipital foramen and are inserted into the posterior part of the lateral plate of the oesophageal pump (Pl. x, fig. 10).

Anterior sphincter of the oesophageal pump (*a.s.oe.p.*). This muscle consists of several very small bands. One of the bands is ring-shaped, and surrounds the membranous part of the oesophagus immediately behind the pharynx. The other bands are attached to the sides of the dorsal and ventral depressions of the membrane (Pl. ix, fig. 5). This muscle has been found by Adler & Theodor (1926) in *Phlebotomus*, and is also present in *Simulium*. It is undoubtedly homologous with the sphincter of the oesophagus of the specialised Diptera, Hippoboscidae (Jobling, 1926), in which it surrounds the anterior part of the oesophagus immediately behind the pharynx.

Posterior sphincter of the oesophageal pump (*p.s.oe.p.*), corresponding to the sphincter in *Anopheles* (Nuttall & Shipley, 1903). This muscle is composed of five ring-shaped bands, which surround the membranous part of the oesophagus immediately behind the oesophageal pump (Pl. ix, fig. 1).

The contraction and the relaxation of the bands of the dilators of the pharynx do not take place simultaneously. The action of these muscles produces the peristaltic movement of the membranous dorsal wall of the pharynx. When the bands of the dilator contract, the anterior part of the oesophagus is closed by the contraction of the anterior sphincter of the oesophageal pump and the blood fills up the lumen of the pharynx. During the relaxation of the bands of the dilator of the pharynx the anterior sphincter is relaxed, whereas the posterior sphincter is contracted and the blood passes into the lumen of the oesophageal pump, which is dilated by the contraction of its own muscles. During the relaxation of the muscles of the oesophageal pump the posterior sphincter is relaxed, and the blood passes towards the crop, since the passage into the pharynx is closed by the contracted anterior sphincter.

Salivary pump muscles (*sl.p.m.*). These are very small muscles arising from the postero-lateral parts of the pharynx and are attached by their very short hyaline tendons to the membranous dorsal surface of the pump (Pl. ix, fig. 4). These muscles are homologous to the salivary valve muscles of the specialised Diptera. In the Hippoboscidae (Jobling, 1926) they arise from the same parts of the pharynx as in all the blood-sucking Nematocera.

The Muscles of the Mandibles.

Abductor of the mandible (*ab.md.*). This is the strongest muscle in the head-capsule. Each abductor arises from the part of the postgena which occupies the space between the occipital foramen and the compound eye (Pl. ix, fig. 2).

Adductors of the mandibles (*ad.md.*). These muscles are almost of the same size as the abductors. Each arises from the lower part of the postgena (Pl. ix, fig. 2).

Accessory adductors of the mandibles (*a.ad.md.*). Comparatively small muscles, each of which arises from the lateral part of the fronto-clypeus (Pl. ix, fig. 2, Pl. x, fig. 7).

All these muscles are connected with the mandibles by the tendons the attachment of which has already been discussed on p. 220.

The Muscles of the Maxillae.

Protractors of the stipites (*pr.s.*). Each of these muscles consists of a very strong band arising from the lateral part of the fronto-clypeus and inserted into the posterior part of the stipes (Pl. ix, fig. 2).

Retractors of the stipites (*r.s.*). Each muscle consists of a very short and broad band arising from the middle part of the genal infold and attached to the inner border of the middle part of the stipes (Pl. ix, fig. 2).

Retractors of the galeae (*r.ga.*). Each of these muscles arises from the posterior arm of the tentorium and is inserted into the posterior process of the galea (Pl. ix, figs. 1 and 2).

Accessory retractors of the galeae (*a.r.ga.*). Each of these muscles consists of two bands arising from the anterior part of the anterior arm of the tentorium. They are inserted into the dorsal surface of the posterior process of the galea (Pl. ix, fig. 2).

Elevators of the maxillary palps (*e.p.*). Very small muscles arising each from the middle part of the stipes and inserted into the dorsal part of the posterior border of the first segment of the maxillary palp (Pl. ix, fig. 2).

Depressors of the maxillary palp (*dp.p.*). These muscles are very small, each of them arising from the middle part of the stipes and inserted into the ventral part of the posterior border of the first segment of the maxillary palp (Pl. ix, fig. 2).

As the galea is fused with the anterior part of the stipes, its protraction depends entirely upon the action of the protractor of the stipes, which is the strongest muscle connected with the maxilla. The retraction of the galea is effected both by the retractor of the stipes and its own retractors. The last-named muscles being inserted at an angle to the longitudinal axis of this part, the retractor proper acts also as an elevator and the accessory retractor as a depressor.

The Muscles of the Labium.

Retractors of the labium (*r.l.*). These muscles are homologous with the retractors of the mentum (theca in the present work) in *Phlebotomus* (Christophers, Shortt & Barraud, 1926), and the retractor of the haustellum in *Musca* (Hewitt, 1914) and in the HIPPOBOSCIDAE (Jobling, 1926). In *Culicoides pulicaris* each of these muscles arises from the part of the postgena immediately at the invagination of the posterior arm of the tentorium and is inserted into the posterior part of the theca (Pl. ix, fig. 1, Pl. xi, figs. 20, 21).

Superior retractors of the first segment of the labella (*s.r.*1.*lb.*). These muscles arise on either side of the base of the theca and each is inserted into the membrane of the postero-lateral parts of the first segment of the labellum (Pl. ix, fig. 1, Pl. xi, figs. 17–19).

Inferior retractors of the first segments of the labella (*i.r.*1.*lb.*). These muscles arise on either side of the postero-ventral part of the theca immediately below the superior retractors. Each of them is inserted into the ventral part of the posterior border of the first segment of the labellum (Pl. ix, fig. 1, Pl. xi, figs. 17–19).

Retractors of the second segments of the labella (*r.*2.*lb.*). These are the longest muscles of the theca. Each of them arises near the middle of the postero-ventral part of the theca and is inserted by a short tendon into the postero-lateral border of the second segment of the labellum (Pl. ix, fig. 1, Pl. xi, figs. 15–19).

With regard to the homology of the muscles arising in the theca, it may be mentioned that the muscles of the theca of *Simulium ornatum* (Pl. x, fig. 13) correspond to those of *Culicoides pulicaris*. Owing to the lack of properly fixed material I was unable to examine the muscles of the same part of the labium in other blood-sucking Nematocera. In the specialised Diptera, such as the MUSCIDAE and HIPPOBOSCIDAE, the number of sets of muscles of the theca is the same as in *Culicoides*, though their points of attachment vary considerably owing to the great modification of the theca and the labella.

Method and Effects of Biting.

In the foregoing pages the position of the mouth-parts with regard to each other has been described from mounted specimens, in which it is very difficult to understand the action of the parts in biting and their position during the sucking of blood. In order to elucidate this point several *Culicoides vexans* and *C. obsoletus* were allowed to feed on the forearm. During the feeding they were observed under the binocular microscope at a magnification of one hundred. As these flies are very rapid feeders, gorging themselves in about three minutes, the beginning of the act of biting is very difficult to observe.

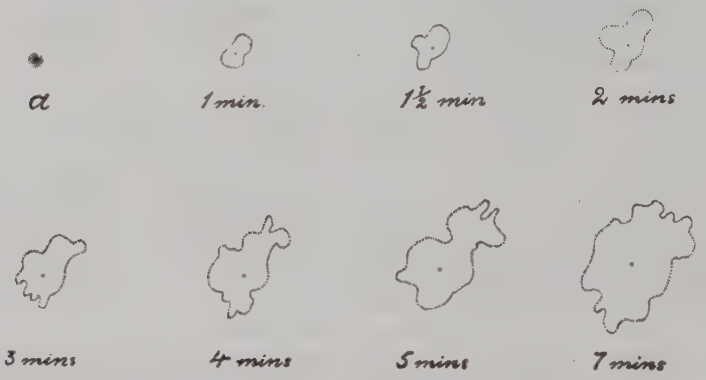

Fig. 10. Growth of oedematous swelling, in minutes, produced by bite of *Culicoides obsoletus* (natural size) ; *a*, appearance of puncture immediately after bite.

It was noticed that the labrum-epipharynx, the hypopharynx, and the mandibles interposed between these two parts, compose together a piercing stylet which performs forward and backward movements during biting. When these mouth-parts have penetrated a little more than half of their length into the skin the protraction and retraction cease. During the sucking of the blood the mandibles are not withdrawn to the sides, but by the structure of their middle parts (described on p. 220) they are maintained in the space between the labrum-epipharynx and the hypopharynx. Thus the food canal is formed by them and the labrum-epipharynx, as has already been indicated by Leon (1924).

Besides the movement which the mandibles perform in association with the labrum-epipharynx and the hypopharynx, they may be abducted and adducted by the action of their own muscles. Of course, this movement is limited by the length of the groove in which the process of the left mandible is inserted.

The galeae of the maxillae are invisible in the living specimens, since they are weakly pigmented and are obscured by the other mouth-parts. Only the study of

the muscles of the maxilla gives some indication of the movement of the galea during the piercing of the skin. The main movement of these parts apparently consists of protraction and retraction.

The labium does not act as a piercing stylet, but serves to hold the other mouth-parts in position during biting. When the labrum-epipharynx, the hypopharynx, the mandibles and the maxillae, penetrate into the skin, they pass between the segments of the labella, which are pressed against the skin round the puncture. During biting the segments of the labella become gradually retracted and bent under at an angle to the theca, which is also retracted by the contraction of its own muscles. By this means at the moment of piercing the labium is gradually shortened, thus enabling the other mouth-parts to penetrate the skin.

Immediately after the fly has withdrawn its mouth-parts from the puncture there appears a small drop of blood, and in a few seconds there develops round the puncture a whitish oedematous swelling with a very irregular outline, which quickly increases in size (text-fig. 10). The intense irritation caused by the bite of *Culicoides* begins at the moment of piercing and lasts from one to several days according to the species. Scratching the skin increases the irritation as well as the size of the swelling and prolongs their duration. Moreover, by scratching it is very easy to tear the skin from the swelling; the resulting sore heals much more slowly than a sore produced by an accidental cut or scratch, being also liable to bacterial infection.

The irritation and swelling caused by the bite of *C. pulicaris* is of very short duration and in many cases disappears on the following day, whereas the bite of *C. vexans*, and more particularly of *C. obsoletus*, produces a more intense irritation, which may last more than a week, the swelling being very distinct on the second and in many cases even the third day after the bite.

The popular idea that the irritation of the bite can be relived by the application of " washing soda " appears to be not without foundation. Certain experiments carried out by me have shown that if the lesion is moistened and rubbed with a crystal of sodium carbonate, which amounts to the application of a concentrated solution, the irritation ceases in a few seconds, and does not recur. Furthermore, the swelling also subsides very rapidly. The same result is obtained even if the application is not made till 24 hours have elapsed.

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Explanation of Reference Lettering.

a.ad.md.	Accessory adductor of mandible.
a.ad.sc.	Accessory adductor of scape.
a.a.t.	Anterior arm of tentorium.
ab.md.	Abductor of mandible.
ab.sc.	Abductor of scape.
a.d.d.	Anterior dorsal dilator of oesophageal pump.
ad.md.	Adductor of mandible.
ad.sc.	Adductor of scape.
a.e.s.	Arm of epicranial suture.
a.r.ga.	Accessory retractor of galea.
a.s.oe.p.	Anterior sphincter of oesophageal pump.

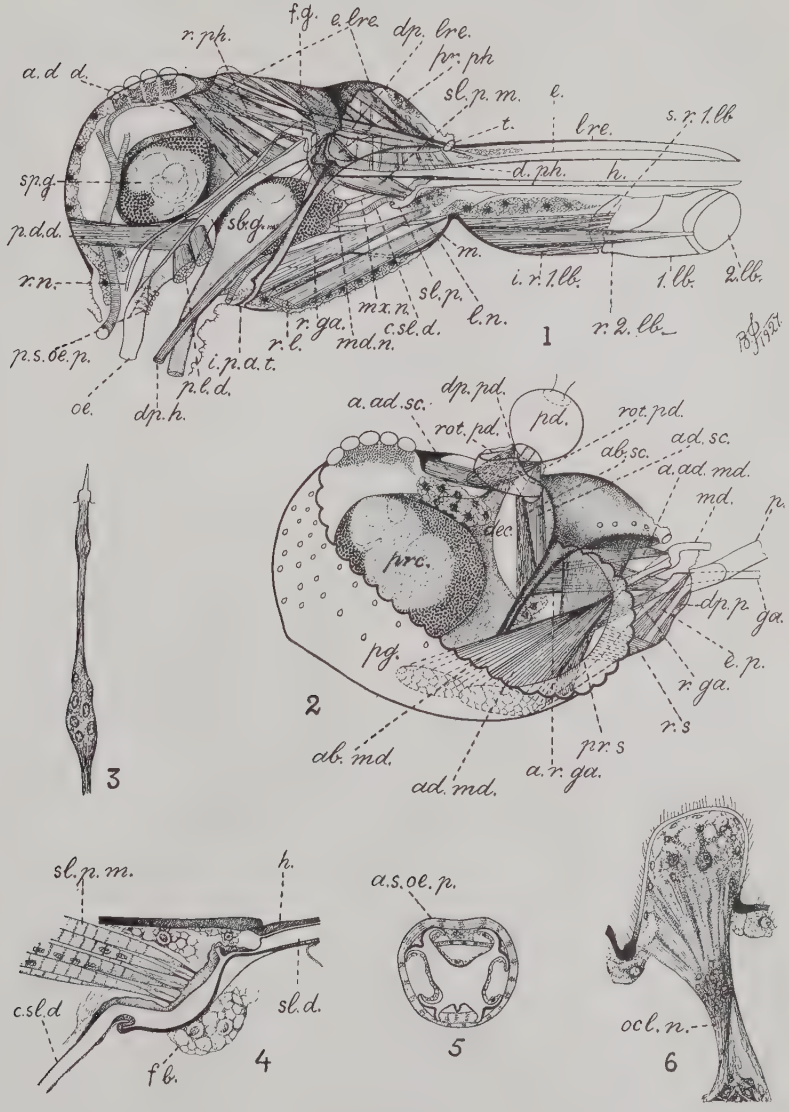
a.v.	Apodeme of vertex.
b.m.	Basantennal membrane
c.	Cardo.
c.e.	Compound eye.
co.	Cornu.
c.sl.d.	Common salivary duct.
d.	Depression.
dec.	Deutocerebrum.
d.ph.	Dilator of pharynx.
dp.h.	Depressor of head.
dp.lre.	Depressor of labrum-epipharynx.
d.p.oe.p.	Dorsal plate of oesophageal pump.
dp.p.	Depressor of palp.
dp.pd.	Depressor of pedicle.
e.	Epipharynx.
e.lre.	Elevator of labrum-epipharynx.
e.p.	Elevator of palp.
e.s.	Epicranial suture.
f.	Flagellum.
f.b.	Fat-body.
fc.	Fronto-clypeus.
fc.a.	Fronto-clypeal apodeme.
f.g.	Frontal ganglion.
g.	Gena.
ga.	Galea.
g.c.	Ganglionic cell.
g.i.	Genal infold.
g.s.	Gustatory sensilla.
h.	Hypopharynx.
hp.	Hypoderm.
i.a.a.t.	Invagination of anterior arm of tentorium.
i.p.a.t.	Invagination of posterior arm of tentorium.
i.r.1.lb.	Inferior retractor of first segment of labellum.
k.th.	Keel of theca.
l.	Labium.
lb.	Labellum.
lc.s.	Laterocervical sclerite.
lg.	Ligula.
l.n.	Labial nerve.
l.p.fc.	Lateral part of fronto-clypeus.
l.p.oe.p.	Lateral plate of oesophageal pump.
l.pr.	Lateral part of labrum.
lre.	Labrum-epipharynx.
lr.n.	Labral nerve.
l.th.	Lateral teeth of labrum-epipharynx.
m.	Mentum.
md.	Mandible.
md.c.	Mandibular condyle.
md.n.	Mandibular nerve.
m.pr.	Median part of labrum.
mx.n.	Maxillary nerve.
o.	Occiput.
o.c.	Occipital condyle.
ocl.	Ocellus.
ocl.n.	Ocellar nerve.

oe.	Oesophagus.
oe.p.	Oesophageal pump.
o.f.	Occipital foramen.
ol.p.	Olfactory pit.
p.	Palp.
p.a.t.	Posterior arm of tentorium.
pd.	Pedicle.
p.d.d.	Posterior dorsal dilator of oesophageal pump.
pg.	Postgena.
ph.	Pharynx.
p.l.d.	Posterior lateral dilator of oesophageal pump.
p.n.	Palpal nerve.
p.p.ga.	Posterior process of galea.
p.p.lr.	Posterior process of labrum.
pr.ph.	Protractor of pharynx.
prc.	Protocerebrum.
pr.s.	Protractor of stipes.
p.s.oe.p.	Posterior sphincter of oesophageal pump.
r.f.g.	Root of frontal ganglion.
r.l.	Retractor of labium.
r.ga.	Retractor of galea.
r.n.	Recurrent nerve.
rot.pd.	Rotators of pedicle.
r.ph.	Retractor of pharynx.
r.s.	Retractor of stipes.
r.2.lb.	Retractor of second segment of labellum.
s.	Stipes.
sb.g.	Suboesophageal ganglion.
sc.	Scape.
sl.d.	Salivary duct.
sl.p.	Salivary pump.
sl.p.m.	Salivary pump muscle.
s.o.	Sense organ.
sp.g.	Supraoesophageal ganglion.
s.r.1.lb.	Superior retractor of first segment of labellum.
t.	Torma.
th.	Theca.
tn.	Tendon.
tn.a.ad.md.	Tendon of accessory adductor of mandible.
tn.ab.md.	Tendon of abductor of mandible.
tn.ad.md.	Tendon of adductor of mandible.
tr.	Trachea.
trc.	Tritocerebrum.
t.th.	Terminal teeth of labrum-epipharynx.
v.	Vertex.
1.lb.	First segment of labellum.
2.lb.	Second segment of labellum.
1.p.–5.p.	First five segments of palp.

Explanation of Plate IX.

Figs. 1–5. *Culicoides pulicaris*, L.

Fig. 1. Longitudinal section through middle part of head. ×200.
,, 2. Longitudinal section through lateral part of head. ×200.
,, 3. Gustatory sensilla of second segment of labellum. ×1,000.
,, 4. Longitudinal section through salivary pump. ×600.
,, 5. Transverse section through anterior part of oesophagus, showing anterior sphincter of oesophageal pump. ×530.
,, 6. *Culicoides vexans*, Staeg., longitudinal section through ocellus. ×600.



Mouth-parts of *Culicoides*.

Explanation of Plate X.

Figs. 7–10. *Culicoides pulicaris*, L.

Fig. 7. Transverse section through middle of fronto-clypeus and pharynx. ×400.

,, 8. Transverse section through posterior part of fronto-clypeus and pharynx. ×400.

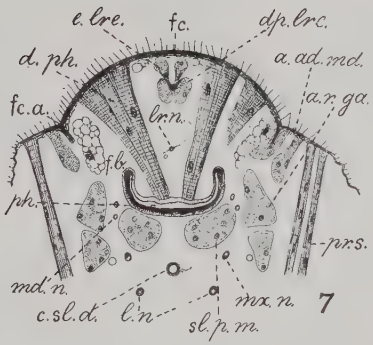
,, 9. Transverse section through anterior part of oesophageal pump, showing attachment of anterior dorsal dilators (*a.d.d.*). ×540.

,, 10. Transverse section through posterior part of oesophageal pump, showing attachment of posterior dorsal (*p.d.d.*) and lateral (*p.l.d.*) dilators. ×540.

,, 11. *Culicoides vexans*, Staeg., transverse section through middle of mouth-parts, showing position of processes and depressions of mandibles when mouth-parts are at rest. ×540.

,, 12. *Phlebotomus major*, transverse section through middle of mouth-parts, showing their position at rest ; cellular structure omitted. ×600.

,, 13. *Simulium ornatum*, L., transverse section through posterior part of theca, showing position of mandibles at rest. ×180.



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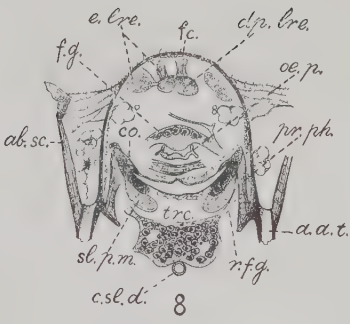

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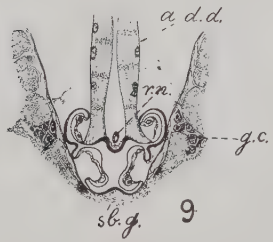

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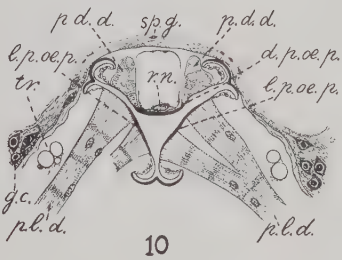

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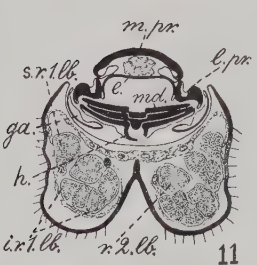

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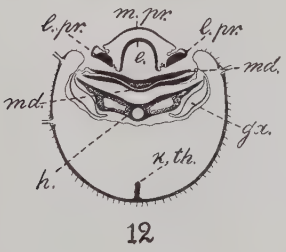

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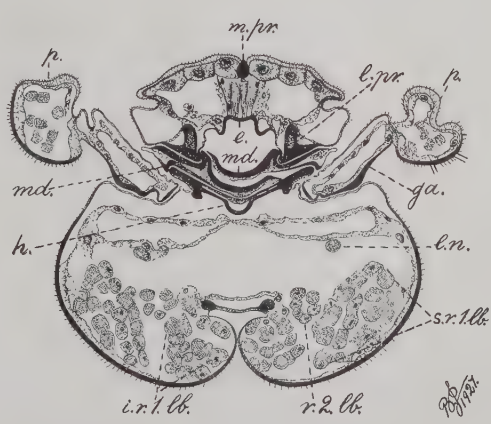

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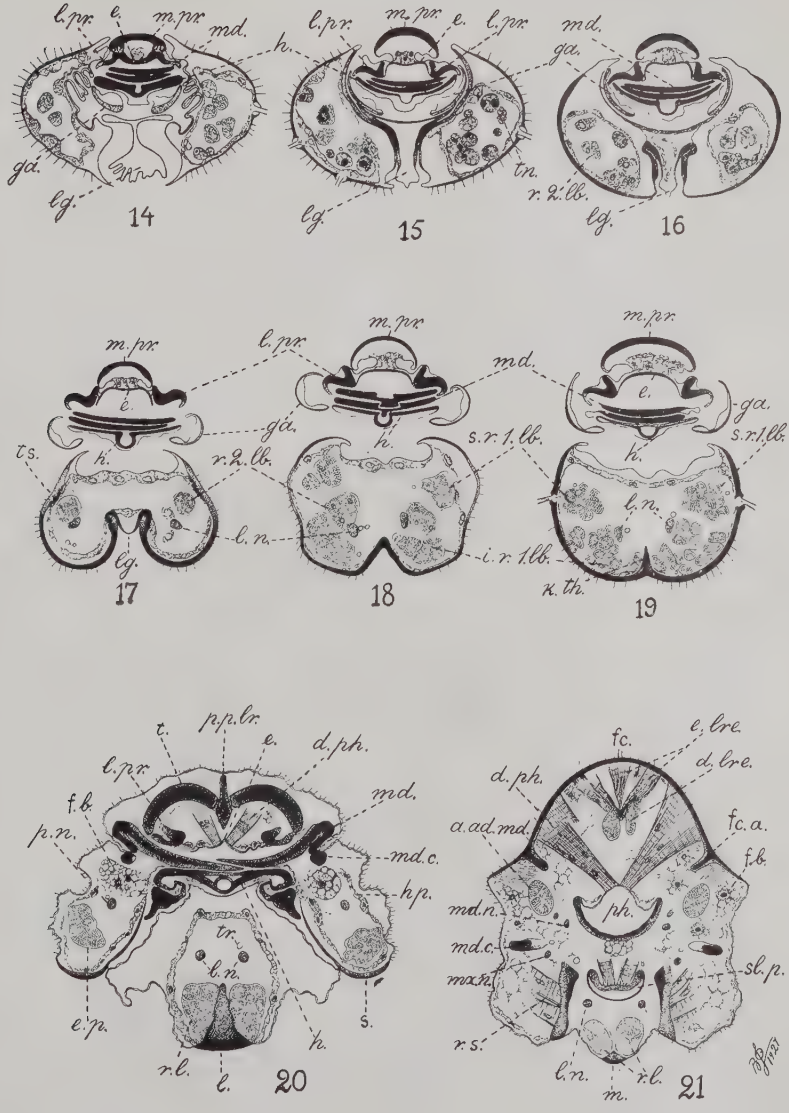
Mouth-parts of *Culicoides*, *Phlebotomus* and *Simulium*.

Explanation of Plate XI.

Figs. 14–21. *Culicoides pulicaris*, L.

Fig. 14. Transverse section through middle part of second segment of labellum. ×540.
,, 15. Transverse section through anterior part of first segment of labellum. ×540.
,, 16. Transverse section through middle part of first segment of labellum. ×540.
,, 17. Transverse section through posterior part of first segment of labellum. ×540.
,, 18. Transverse section through middle of mouth-parts, showing position of processes and depressions of mandibles when mouth-parts are at rest. ×540.
,, 19. Transverse section through posterior part of mouth-parts. ×540.
,, 20. Transverse section through base of mouth-parts. ×540.
,, 21. Transverse section through anterior part of head, showing position of pharynx (*ph.*) and salivary pump (*sl.p.*). ×400.



Transverse sections of mouth-parts of *Culicoides*.

Forearm showing œdematous swellings caused by bites of *Culicoides vexans* and *C. obsoletus*.

STUDIES IN AFRICAN TACHINIDAE (DIPTERA). III.

By C. H. Curran,
Ottawa, Canada.

The present paper deals with a small collection of Tachinidae received from Mr. H. Hargreaves from Uganda, together with other material of the various species forwarded by the Imperial Bureau of Entomology. The types of the new species, unless otherwise stated, will be deposited in the British Museum of Natural History.

Actia nana, sp. n.

Black; thorax thickly cinereous pollinose; tibiae and apex of the scutellum yellowish. Length, 3 mm. Most closely related to *mitis*, Curran, but at once distinguished by the black femora.

♀. *Head* pale reddish in ground-colour, the occiput mostly black, white pollinose; frontal vitta reddish, the bristles strong; cheeks one-third as wide as eye-height. Palpi reddish yellow, broadened and flattened on the apical half. Antennae reddish, the third segment at least half blackish, about twice as long as wide; arista brown on the apical third, its penultimate segment twice as long as wide. *Thorax* with dense cinereous pollen, which has a brownish tinge on the disc of the mesonotum and scutellum; apex of scutellum broadly luteous. Three sterno-pleurals. *Legs* blackish, the broad apex of the anterior femora, tips of the posterior four and all the tibiae, reddish yellow. *Abdomen* shining black, the tips of the basal three segments yellow, the bases of the apical three with rather narrow, medianly interrupted, white pollinose fasciae. Basal segment without dorsal bristles, the second with one pair, the third and fourth each with a row of marginals. *Wings*: the ultimate section of the fifth vein is longer than the preceding section; first vein bristled on apical third above and below; third vein bristled to opposite the posterior cross vein, the fifth vein bare.

Type ♀ and one ♀ paratype, Kampala, Uganda, 7.iii.1927 (*H. Hargreaves*), from a Noctuid moth (*Earias* sp.).

Phorocera blepharipa, Br. & Berg.

♀, Kampala, Uganda, 6.i.1921 (*H. Hargreaves*), ex *Naroma signifera*, Walker; ♂, Kampala, 19.xi.1917 (*C. C. Gowdey*).

Phorocera divergens, sp. n.

Black, the sides of the intermediate abdominal segments broadly reddish; second abdominal segment with long marginals; no discals. Length, 11 to 13 mm.

♂. *Head* silvery white pollinose, the front more greyish, five-eighths as wide as either eye, widening anteriorly; eleven pairs of frontals, the upper pair strong and reclinate, the lower four or five below the base of the antennae, the frontal hair bristle-like except above; ocellars long and strong; outer verticals absent; frontal vitta black, as wide as parafrontal at middle. Pile white. Cheeks one-third as wide as eye-height, with coarse hair. Parafacials about as wide as third antennal segment, scarcely narrowed below. Facial ridges with strong bristles on lowest three-fourths, the vibrissae situated very little above the oral margin. Palpi black. Antennae black, the third segment little more than twice as long as the second; arista thickened and tapering to the middle. *Thorax* grey pollinose, the vittae conspicuous. Dorsocentrals, 3–4; sternopleurals, 2–1; hair black. Scutellum more or less reddish apically, with four pairs of marginals, the apical pair cruciate, and one pair of discals.

Legs black ; middle tibiae with two antero-dorsal bristles ; posterior tibiae ciliate, with a longer bristle beyond the middle ; pulvilli short. *Wings* cinereous hyaline ; third vein with two or three basal setae ; bend of fourth vein with short, weak fold. Squamae white. Halteres reddish, with brown knob. *Abdomen* greyish pollinose, the exceptionally large sexual patch extending upwards to occupy more than two-thirds of the dorsum of the third segment, which is shining beneath the rather thin hair. Pile appressed. First and second segments each with one pair, the third and fourth each with row of marginals.

♀. Front three-fourths as wide as eye ; two pairs of strong orbitals ; outer verticals half as long as verticals ; no sexual patch, the abdomen evenly pollinose.

Type ♂, Kampala, Uganda, 1922 (*H. Hargreaves*) ; allotype ♀, Entebbe, Uganda, 20.ii.1911 (*C. C. Gowdey*). Paratypes : ♂♀ with same data as same sex of types.

Phorocera venusta, sp. n.

Blackish blue, rather thickly grey pollinose ; wings brownish on the anterior third and along the veins ; second and third abdominal segments each with pair of discals. Length, 9·5 to 11 mm.

♂. *Head* greyish white pollinose, the parafacials, cheeks and posterior orbits silvery. Front scarcely as wide as either eye, the vitta three-fourths as wide as parafrontal at middle ; nine or ten pairs of frontals, the lower four or five below the base of the antennae, the upper two reclinate, situated outside the regular frontal row and simulating orbitals ; frontal hair sparse, long and coarse ; ocellars long and strong ; outer verticals absent ; occipital pile white. Cheeks one-third as wide as eye-height, with sparse, coarse hair. Parafacials strongly narrowing below, at their middle only about one-third as wide as third antennal segment. Palpi black. Vibrissae situated almost level with oral margin, the ridges bristled on the lowest three-fourths and without hairs outside. Antennae reaching almost to the oral margin, the third segment broad, five times as long as the second ; arista thickened almost to the middle. *Thorax* : dark mesonotal vittae conspicuous in front of the suture, weak behind. Dorsocentrals, 3–4 ; sternopleurals, 2–1 ; 4 pairs of marginal scutellars, the apical pair cruciate. *Legs* black ; middle tibiae with two antero-dorsal bristles ; posterior tibiae not ciliate ; pulvilli short. *Wings* brownish anteriorly ; no appendage at bend of fourth vein. Squamae white. Halteres reddish, with brownish knob. *Abdomen* with the basal three segments rather broadly shining apically except towards the middle, the apical segment quite thickly pollinose. First and second segments each with one pair, the third and fourth with a row of strong marginals ; second and third segments each with pair of discals, the fourth with two rows. Hair of basal segments appressed.

♀. Third antennal segment about four times as long as second ; front same width as in ♂.

Type ♂ and allotype ♀, Mount Ruwenzori, Uganda, ♂ 17.v.1911, ♀ 16.v.1911 (*C. C. Gowdey*). Paratypes : ♂♀, Mt. Ruwenzori, 16.v.1911 ; 2♀♀, Kampala, Uganda, 17.ii.1915 (*C. C. Gowdey*), reared from *Zonobombyx angulata* ; ♀, 5 to 7 miles into Kenya Forest, near Lueke River, 9–10.ii.1911 (*T. J. Anderson*).

Zenillia hargreavesi, sp. n.

Related to *angulicornis*, Villeneuve, but with three antero-dorsal bristles on the middle tibiae, and to *vara*, Curran, from which it is distinguished in the same way. Black ; cinereous pollinose ; palpi, scutellum and tibiae dull reddish. Length, 9 mm.

♂. Head whitish pollinose, the parafacials and posterior orbits silvery. Front two-thirds as wide as either eye ; nine pairs of frontals, the lower three below the

base of the antennae, the upper two reclinate, the hair sparse and rather fine ; ocellars long and strong ; outer verticals one-third as long as verticals ; no setae behind the occipital cilia ; occipital pile white. Cheeks one-tenth as wide as eye-height, with coarse black hair. Parafacials twice as wide above as below, at the middle half as wide as the third antennal segment. Facial ridges, in profile, gently convex on the lower half or less, with three or four bristles above the vibrissae which are situated on a level with the oral margin. Palpi reddish. Antennae black, reaching almost to the oral margin, the third segment broad, swollen at the base above, five times as long as the second. Arista thickened on the basal third. Pile of the eyes cinereous. Frontal vitta brown, as wide as either parafrontal. *Thorax* thickly pollinose, the narrow vittae distinct. Dorsocentrals, 3–4 ; sternopleurals, 2–1 ; 4 pairs of marginal scutellars, the apical pair cruciate. Scutellum luteous, the base broadly blackish. *Legs* black ; tibiae obscurely reddish ; middle tibiae with three or four antero-dorsal bristles ; posterior tibiae sparsely ciliate ; pulvilli elongate. *Wings* cinereous hyaline ; third vein with two basal setae. Squamae white. Halteres reddish, with darker knob. *Abdomen* cinereous pollinose ; the second segment on the apical fifth or less, third on apical fifth, widening to half at the sides, and the apical third of the fourth segment, shining black. First and second segments each with a pair of marginals, the third and fourth each with a row, the fourth with the hair bristle-like and erect.

♀. Two pairs of orbitals ; front scarcely wider than in ♂ ; outer verticals three-fourths as long as verticals ; pulvilli short.

Type ♂, allotype ♀ and one ♂ paratype, Kampala, Uganda, 16.v.1923 (*H. H. Hargreaves*).

Sericophoromyia, Austen.

The following table will separate the species belonging to this genus, although I have been unable to identify the genotype.

Key to the Species of Sericophoromyia.*

1. Mesonotum clothed with black hair, only the notopleura, humeri behind and the posterior calli, with pale hair 2
   Mesonotum with at least a large amount of the hair fine and pale-coloured 5
2. Not more than the lower third of the facial ridges with bristles 3
   Facial ridges bristled to above the middle (Ruwenzori) ... ... *sericea*, sp. n.
3. Legs testaceous ... ... *ruficrura*, Villen.
   Legs black, the tibiae more or less reddish 4
4. Sides of the scutellum with abundant, fine, pale hairs ; abdomen of the male tapering beyond the second segment ... ... *claripilosa*, Aust.
   Scutellum without dense pale hair laterally ; sides of the abdomen almost parallel ... ... *marshalli*, Villen.
5. Mesonotum with violaceous reflections ; abdomen pitchy-brown, the second and third segments white pollinose on the anterior half (Kilimanjaro) ... ... *lanuginosa*, Speis.
   Mesonotum wholly opaque pollinose, the ground-colour sometimes moderately evident, but never with violet reflections ; abdomen broadly reddish laterally on the basal half 6

6. Front with fine, pale yellow hair, at most a few scattered coarse black ones ; femora chiefly reddish ... ... *amplipilosa*, sp. n.
   Front clothed with black hair 7

* *Tachina dasyops*, Wied., the genotype, I have not been able to determine among the material on hand. From the description it should have the third abdominal segment in the male broadly reddish laterally.

7. Pile of the parafacials wholly yellow, fine; femora black, their apical third pale below; only one pair of strong bristles on the first and second abdominal segments, some weaker ones between them ... *quadrata*, Wied.
Pile of the parafacials mostly black; femora reddish, more or less blackish basally and above; two almost equally strong pairs of marginals on the first and second abdominal segments and usually several weaker adjacent ones ... ... *conformis*, sp. n.

Sericophoromyia sericea, sp. n.

Black; palpi reddish; sides of abdomen broadly reddish yellow on more than the basal half; legs black. Length, 10·5 mm.

♂. *Head* yellow pollinose, the facial depression and cheeks more whitish; front three-sevenths as wide as eye, with long, black hair. Occipital pile tawny above, yellow below and on the cheeks. Parafacials with black hair, reddish in ground-colour. Facial ridges bristled on lowest two-thirds. Palpi yellowish. Antennae black, extending to the oral margin, the third segment broad, more than three times as long as the second; arista thickened almost to the middle, tapering, not stout. Pile of the eyes yellowish. *Thorax* reddish brown pollinose, very weakly vittate, the mesonotum black-haired except on the sides. Scutellum brownish yellow, yellow-haired, with some black bristly hairs on the disc. Dorsocentrals, 3–4; sternopleurals, 1–1; prosternum with yellow pile laterally. *Legs* black; apices of the femora reddish, the femora with reddish pile posteriorly on the anterior four, anteriorly on the posterior pair, and on the lower surface. Middle tibiae with three or more antero-dorsal bristles; posterior tibiae closely ciliate. Pulvilli short. *Wings* cinereous hyaline, with brownish tinge in front and along the veins; third vein with a single basal seta. Squamae whitish; halteres reddish. *Abdomen* black, the lateral posterior half of the first segment, the second except a large, median posterior triangle which reaches the base, and the basal fourth of the third segment except in the middle yellowish, densely yellowish white pollinose, the third segment thinly pollinose, the fourth shining. First and second abdominal segments each with two pairs of marginals, the third and fourth each with a row. Abdomen with fine yellow hair and with coarse, erect, bristly hairs intermixed, the fourth segment without pale hair on the apical half. No sexual patch.

Type ♂, Mount Ruwenzori, Uganda, 15.v.1911 (*C. C. Gowdey*).

Sericophoromyia ruficrura, Villeneuve, Ann. S. Afr. Mus., xv, p. 481, 1916.

Three ♂♂, Kampala, Uganda, 10.xi.1916 (*C. C. Gowdey*); ♂, E. of Mt. Mlanje, Portuguese East Africa, 3–7.x.1913 (*S. A. Neave*).

Sericophoromyia claripilosa, Austen, Tr. Zool. Soc. London, p. 95, 1909.

Two ♂♂, Mount Mlanje, Nyasaland, 14.xi.1913 (*S. A. Neave*).

Sericophoromyia marshalli, Villeneuve, Ann. S. Afr. Mus., xv, p. 480, 1916.

Two ♂♂ and 4 ♀♀, from Barberton, iv.1920 (*H. K. Munro*).

In the ♀ of this species the pile of the face is sparse and very pale yellowish, in the ♂ darker. The cheeks bear short, abundant pale pile, the facial ridges have only two or three very small bristles above the vibrissae; the middle tibiae bear a single, long, antero-dorsal bristle before the middle, the scutellum bears four pairs of marginal bristles including the cruciate pair and lacks pale pile laterally, and the second abdominal segment bears a pair of very strong marginals. In the ♂ the marginals are lacking on the second segment and there is a trace of pale pile on the sides of the scutellum.

Sericophoromyia amplipilosa, sp. n.

Femora reddish except the broad bases of the anterior four and basal half of the upper surface of the hind pair ; tibiae dark reddish, with black bristly hair ; thorax wholly clothed with fine, crinkly pile. Length, 10 mm.

♀. *Head* with front nine-tenths as wide as either eye, wholly clothed with pale pile ; frontals weak for ♀, the upper two pairs reclinate ; two pairs of orbitals ; ocellars strong, the post-ocellars equally long but fine ; outer verticals three-fourths as long as verticals ; black occipital cilia extending to lower sixth of eye, every second or third one long ; occipital pile cinereous yellowish ; cheeks with long, parafacials with shorter, yellowish-tinged pile. Facial ridges with strong bristles on the lower two-thirds or more, the vibrissae situated level with the oral margin. Parafacials half as wide below as the third antennal segment, as wide as the segment at base of antennae. Head whitish pollinose, the front ochreous above, the occiput cinereous, the front rather bare above. Palpi pale yellow, greatly widened on the apical half, clothed with black bristly hairs. Antennae black, the incisures and base of the third segment reddish ; third segment somewhat tapering apically, three times as long as the second, its apex rounded ; arista slender, reddish brown. Eyes with pale yellowish pile. *Thorax* with the pollen dense, on the dorsum rather olivaceous, grey on the pleura. Pile wholly crinkly, fine, yellow, the bristles black ; scutellum with only a few black bristly hairs, the crinkly pile occupying the lateral fourth and narrow base, three pairs of marginals, the apical pair weak and cruciate, a pair of fine discals. Acrostichals, 3–3 ; dorso-centrals, 3–4 ; sternopleurals, 1–1. *Legs* reddish ; tarsi black ; femora black basally ; femora below, the anterior four behind, the hind pair in front, yellowish pilose and grey pollinose. *Wings* cinereous hyaline, somewhat yellowish in front towards the base ; third vein with a single weak basal seta. Squamae whitish, the upper lobe and border yellowish. *Abdomen* black ; first segment except in the depression, second except a large, transverse posterior triangle reaching narrowly to the base, and the narrow base of the third towards the sides, reddish ; basal third or less of the second and third segments cinereous white pollinose, the segments elsewhere very thinly so, the fourth segment obscurely brownish pollinose basally. First and second segments each with a pair of strong marginals, the third with a row, the fourth with three irregular rows of bristles on the apical two-thirds and many strong, hair-like bristles. Pile of abdomen fine and yellowish, the abdomen also with numerous fine, bristle-like hairs except on the heavily pollinose fasciae. From anterior view there is no continuous sericeous sheen. The hair of the genitalia is wholly black, the sternites each with two or three pairs of fine marginal bristles.

Type ♀, Barberton (*H. K. Munro*).

Sericophoromyia quadrata, Wied.

Tachina quadrata, Wiedemann, Ausser. Zweifl., ii. p.318, 1830.

Four ♂♂, Elliot, S. Africa, 12.v.1924 (*H. K. Munro*) ; ♂, Willow Grange, Natal, 23.xii.1913 (*R. C. Wroughton*).

S. quadrata is close to *dasyops*, Wiedemann, but has the third abdominal segment coloured as in *conformis*, Curran. The front bears long blackish hair, while the parafacials are clothed with fine yellow pile ; front half as wide as either eye ; pile of thorax wholly fine, pale yellowish, no coarse black hairs ; some fine black scutellars, three pairs of marginals including the cruciate apical pair, a fourth very weak pair often present. Femora black ; tibiae red, the middle pair with a row of about five antero-dorsal bristles terminating in a long one a little beyond the middle ; pulvilli small, brown. Abdomen as in *conformis* but with more extensive yellowish-tinged pollen, especially on the broad bases of segments 2 to 4.

Sericophoromyia conformis, sp. n.

Legs largely reddish ; thorax on the whole surface with fine, yellowish-tinged pile, the mesonotum with some scattered coarse, black hairs ; sides of the abdomen broadly reddish on the basal half. Length, 11 to 14·5 mm.

♂. *Head* : face mostly reddish in ground-colour, the head elsewhere black, but so densely pollinose as entirely to conceal the ground, the pollen yellowish on the front and occiput, elsewhere whitish with more or less yellow tinge. Front about three-eighths as wide as eye, the sides scarcely diverging in front, but the front projects well above the eyes ; parafrontals less thickly pollinose than elsewhere, together with the parafacials, clothed with fairly abundant long black hair ; eleven or twelve pairs of long, rather fine, frontals, the upper ones somewhat shorter, the dorsal pair reclinate ; ocellars as strong as strongest frontal, the post-ocellars long but slender ; verticals long and slender, the outer pair three-fourths as long ; black occipital cilia extending almost to the lower edge of the eyes, the pile cinereous yellow ; cheeks with coarse yellow hair. Parafacials bare on the lower third ; vibrissae situated level with the oral margin, the ridges with long bristles on the lowest two-thirds. Parafacials two-thirds as wide as third antennal segment, widened above. Palpi yellowish, broad on the apical half, black-haired. Antennae black, the incisures reddish ; third segment three times as long as the second and three times as long as wide, broad, its apex rounded below ; arista brown, slender, tapering, weakly pubescent on the basal half. Eyes with tawny pile. *Thorax* aeneous, the ground-colour almost hidden by the ochreous pollen of the mesonotum and greyish of the pleura ; humeri, lateral margins narrowly and a medianly broadened prescutellar fascia, reddish. Scutellum rusty reddish, paler apically, yellow pilose and coarsely black-haired, with three pairs of marginals including the weaker, cruciate apical pair, the sides with dense crinkly hair. Dorsocentrals, 3–4 ; sternopleurals, 1–1. *Legs* : femora reddish, more or less blackish above and sometimes basally, the anterior pair rarely as much as half black, clothed beneath (the anterior four posteriorly and the hind pair anteriorly) with fine yellow pile. Tibiae dark reddish, but the black hair is so dense as to make them appear brown or blackish ; tarsi black. Pulvilli small, reddish. *Wings* cinereous hyaline, broadly yellow in front on the basal half ; third vein with two basal bristles. Squamae whitish, with yellowish border, appearing wholly yellowish in some views. Halteres reddish yellow. *Abdomen* with the first segment black in the depression, elsewhere reddish ; second reddish, with a large posterior triangle (of variable width) reaching to the base ; third segment black, with the narrow base reddish except on the median fourth, the fourth wholly shining black. Second, third, and basal third of fourth segment, with fine, not abundant, long, yellowish pile and thin, rather greyish pollen, so that the whole abdomen appears sericeous from anterior view, except for the shining apex ; in addition, these segments bear sparse black bristly hair dorsally. First and second segments each with two to six pairs of marginals, two pairs always strong, the others, if present, weaker ; third segment with a row of very strong marginals, the fourth with the apical two-thirds clothed with numerous bristles of various sizes, but there are three or four rows of stronger ones, the bristles extending on to the underside. Each sternite bears two or three pairs of weak bristles.

♀. Front five-sevenths as wide as either eye, noticeably widening anteriorly ; about nine pairs of frontals, the upper two reclinate ; two pairs of orbitals ; face rather silvery white. Abdominal pollen more conspicuous, white, the pale pile somewhat shorter ; second abdominal segment often with much more extensive black colouring.

Described from 24 specimens from South Africa : *Type* ♂, Port Shepstone, 29.viii.1920 ; allotype ♀, East London, 25.iv.1924. Paratypes : 2♂♂, Port Shepstone, 5, 8.vii.1917 ; ♂, Barberton, 2.v.1913 ; ♀, Pretoria, 16.v.1913 ; ♀, East London, 25.v.1924 ; ♂♀, East London, 18.vi., 5.vii.1924 (all *H. K. Munro*) ; ♂, Durban,

Natal, 1903 (*G. F. Leigh*); ♂, New Hanover, Natal, vi.1914; 2♂♂3♀♀, Rosebank, Natal, iv.1926 (*R. W. E. Tucker*); 1♂4♀♀, Durban, Natal, 29.viii.1924, 29.xii.1917; 3♀♀, Pretoria, Transvaal, 30.v., 3.vi.1919.

This species has been confused with *quadrata*, Wiedemann, which, however, has black legs and many other differences. It can hardly be *dasyops*, Wiedemann, as in that species the third abdominal segment should be reddish with a black median vitta.

Dejeania, Desvoidy.

I present a key for the separation of the species belonging to this genus, together with descriptions of two new forms.

Table of Species.

1. Abdomen wholly blackish, shining 2
   Abdomen mostly reddish or yellowish 4
2. Orbital cilia do not extend to the lower edge of the eyes 3
   Orbital cilia extend to the lower edge of the head ... ... *abyssinica*, Villen.
3. Mesonotum with coarse black hair ... ... *pertristis*, Villen.
   Mesonotum wholly fine yellow pilose ... ... *certima*, Curran.
4. At least the fourth abdominal segment clothed with black hair 5
   Abdomen wholly clothed with long, fine, reddish pile ... *marshalli*, sp. n.
5. Orbital cilia stop well short of the lower edge of the head 7
   Orbital cilia extend to the lower edge of the head 6
6. Antennae reddish; wings yellowish basally ... ... *hecate*, Karsch.
   Antennae mostly brown; wings brownish, with the costal border broadly deeper brown on the basal half ... ... *wollastoni*, Aust.
7. Dorso-centrals, 3–4; parafacials with row of bristly hairs... 8
   Dorso-centrals, 3–3; parafacials with an isolated black bristle below *bombylans*, Wied.
8. Abdomen black-haired above; hair of parafacials black ... *goodeyi*, sp. n.
   Abdomen with only the fourth segment black-haired ... *nigrapex*, Villen.

Dejeania marshalli, sp. n.

Rusty reddish, the mesonotum black except the posterior and lateral margins; abdomen with reddish pile. Length, 12 mm.

♀. *Head* rather thickly pale brassy yellow pollinose, the front thinly so, the parafrontals somewhat darker; frontal vitta dull rusty red, a little narrower than parafrontal opposite; nine pairs of fairly strong frontals, the upper pair stronger and curved outwards, the sparse hair long and black; two pairs of strong orbitals; ocellars as long as upper frontals, parallel, the post-ocellars well developed; outer verticals two-thirds as long as the cruciate verticals; black occipital cilia extending extending to the lowest fifth of the eye. Pile of the occiput reddish, paler below; cheeks with a few long reddish hairs below; parafacials with an entire median row of long bristly hairs, a few of which are reddish; three black bristles along the lateral oral border and several short ones below the vibrissae and two or three above them. Apical section of proboscis about twice as long as head-height, rather ferruginous; palpi twice as long as oral opening, dull reddish yellow, with black hairs. Antennae dark rusty reddish, the third segment chiefly brown, its apex a little oblique, the corners rounded; arista black, the penultimate segment three times as long as wide, the basal segment as long as wide. *Thorax* with the mesonotum olive-black in ground-colour, the sides and posterior margins broadly reddish, the dark colour produced towards the corners of the scutellum, ochreous pollinose, the dark vittae slender, distinct from posterior view; from anterior view there are seen three broad,

dark vittae ; pleura thinly grey pollinose. Pile of thorax sparse, almost all reddish ; discal bristles rather fine. Acrostichals, 3–3 ; dorsocentrals, 3–4 ; sternopleurals, 3 ; scutellum with 3 pairs of marginal bristles and a pair of apical spines, the apical half with stout spines, the pile reddish. *Legs* reddish, the tarsi darkened apically ; coxae and the femora posteriorly and ventrally, with yellow pile. *Wings* greyish brown, the costal region broadly yellowish basally, the yellow area tapering to the middle of the wing. Squamae reddish yellow with darker border. Halteres reddish. *Abdomen* with the pile appearing golden in some lights. First segment with about six spines on either side of the middle, the two groups broadly separated ; second segment with a marginal row of almost contiguous spines which stop at the lateral margin ; third segment with similar row, but they extend as bristles on to the venter ; apical half of the fourth segment with ordinary bristles, the segment strongly narrowed to the buttocks-shaped apex. Each sternite bears a marginal row of stout spines. The hind coxae bear only two or three fine black bristles.

Type ♀, Mount Ruwenzori, Uganda, 15.v.1911 (*C. C. Gowdey*).

This beautiful species is named in honour of Dr. Guy A. K. Marshall, from whom many African TACHINIDAE have been received. It is the only known Ethiopian species with reddish pile on the abdomen and may be at once recognized by this character.

Dejeania wollastoni, Austen, Trans. Zool. Soc. London, xix, p. 93, 1909.

Two ♂♂, Mt. Ruwenzori, Uganda, 15.v.1911 (*C. C. Gowdey*). This is the type locality.

Dejeania gowdeyi, sp. n.

Rather similar in colour to *bombylans*, Wiedemann ; the abdomen is longer and less tapering, the parafacials have a row of bristly hairs and there are four post-sutural dorsocentrals. Length, 14 mm. Reddish yellow, the mesonotum pale olivaceous, the fourth segment with a sub-triangular basal black spot, the apical half of the segment and rectangular lateral spots on the third segment behind, shining reddish brown.

♂. *Head* with shining greyish white pollen, the front and upper part of the occiput yellowish pollinose. Front eight-ninths as wide as either eye, widening anteriorly ; about nine pairs of frontals which become weaker above, with the exception of the divergent upper pair ; a row of five pairs of orbitals, the upper pair divergent, the others proclinate ; ocellars very strong ; verticals cruciate; outer verticals more than half as long as verticals ; post-ocellars short ; frontal hair sparse, bristly, black. A single row of occipital cilia extending to the lower fifth of the eyes ; occipital pile fine, yellow ; cheeks with sparse, coarse, yellow hair below ; one strong and two weak black bristles along the lateral oral margin, three bristles above the vibrissae ; parafacials with a row of about eight bristly hairs, most of which are black, and a secondary row of yellow hairs. Proboscis reddish, its apical section one and one-half times as long as the head, the palpi but little shorter, pale yellow, with black bristly hairs. Antennae shining rusty reddish, the third segment mostly stained with brown, pale pollinose, large, almost as broad as long, its apex oblique, the upper corner broadly rounded, the upper edge convex ; arista brown, pubescent, the penultimate segment as long as the median width of the second antennal segment, the preceding segment about as long as wide. *Thorax* with the mesonotum densely dull ochreous pollinose, the vittae obsolete, the sides, posterior margin broadly, and the scutellum, reddish; pleura white pollinose ; pile on pleura, pale portion of mesonotum and on scutellum, yellow, the hair on the mesonotum black. Acrostichals, 3–3 ; dorsocentrals, 3–4 ; sternopleurals, 2–1, in a small triangle. Scutellum with three pairs of marginal bristles and many spines, the apicals represented by two long,

slightly diverging spines with a shorter, more erect spine between them. *Legs* reddish yellow, the tibiae and tarsi somewhat stained with brownish, the latter brownish apically; pile on the coxae, posterior surface of the anterior and lower surface of all the femora, yellow; hair black. Pulvilli long, brownish yellow. *Wings* greyish, yellow basally and anteriorly as far as the middle. Squamae and halteres reddish yellow. *Abdomen* with the apical two segments rusty reddish, the basal two segments paler. First segment with a group of five or six marginal spines on either side, broadly separated in the middle; second and third segments each with a complete marginal row and several adjacent spines spreading over the apical third at the sides. Fourth segment bare on about the basal third, with numerous spines apically except in the depression, buttocks-shaped apically, its sides narrowed towards the rear. Second to fourth sternites each with a gently arched row of marginal spines; posterior coxae with a single black apical bristle.

♀. Differs only sexually.

Type ♂, Majaba, Uganda, 1.ii.1910; allotype ♀, Mount Ruwenzori, Uganda, 15.v.1911 (both *C. C. Gowdey*).

I am very pleased to name this unusual species in honour of the collector, who has collected many thousands of insects in various British Colonies.

Dejeania nigrapex, Villeneuve, Ann. S. Afr. Mus., xv, p. 470, 1916.

Described from "Cape of Good Hope." I have seen the type, and it is a very distinct species. It has strikingly different genitalia from *gowdeyi*, much more numerous bristles on the fourth abdominal segment, etc.

FURTHER OBSERVATIONS ON MOSQUITO BREEDING IN TREE-HOLES AND CRAB-HOLES.*

By Lawrence H. Dunn,
Entomologist, West African Yellow Fever Commission, Lagos, Nigeria.

The following article includes the results of observations on the number and species of mosquitos breeding in two tree-holes during a period of more than ten months.

The two holes selected for observation were somewhat different in type and were designated according to their formation as " bottle hole " and " basin hole."

Bottle Hole.

The bottle hole was in a dika nut tree, *Irvingia barterii*, growing in the compound of the West African Yellow Fever Commission at Yaba, near Lagos, Nigeria. This hole was situated in the first fork of the tree, at a distance of 3½ feet from the ground, and extended vertically down into the trunk to a depth of 6½ inches. It was about two inches in diameter at the top, or external opening, and widened to nearly five inches at the bottom. It had a water capacity of about 355 cc.

The tree in which this hole occurred stood in the centre of a small clump of closely growing trees at a distance of 16 yards from the Commission Staff House. The thick foliage of the tree prevented water from accumulating in the hole during light rains, but when fairly heavy rains occurred the water trickled down the two main branches forming the first fork and entered the hole. The foliage of this tree and those surrounding it formed a sufficient canopy to protect the hole from sunshine at all times. The constant shade and the form of the hole tended to retard the evaporation of the water which collected.

A small mass of partly disintegrated leaves at the bottom of the hole was left there during the observation in order to avoid changing the natural conditions in the hole. These leaves retained moisture for several days after the water was removed.

Basin Hole.

The basin hole was situated in a mango tree, *Mangifera indica*, in the Commission compound at a distance of 60 yards from the bottle hole tree. This tree had previously been cut down to a height of three feet above the ground. The stump had callused around the edge at the top and new growths more than 10 feet high had sprung up on one side. Insects, decay or other factors had formed a hollow in the centre so that the top of the stump resembled a basin, the callused edge forming the rim. This hole was 8 inches in diameter and 3½ inches deep in the centre. The bottom was quite hard and there were no leaves or débris to retain moisture after the water was removed.

The tree stood at the edge of a large thicket of trees with a small open area in front. This caused the hole to receive so little shade that it was exposed to the sunshine during a considerable part of the day. It was also exposed to the prevailing winds. These factors, combined with the wide and shallow shape of the hole, caused the evaporation of water to be more rapid from this hole than from the bottle hole. Its capacity was approximately 900 cc.

Observations on the mosquito breeding occurring in these two tree-holes were begun on 24th May, 1926, and continued to 14th April, 1927, a period of 325 days.

* The studies and observations on which this paper is based were conducted with the support and under the auspices of the International Health Board, Rockefeller Foundation.

The holes were examined at five-day intervals. All water present at the time of examination, whether mosquito larvae could be noted or not, was collected with a piece of glass tubing and a rubber bulb. After all the water was removed, a small amount was always drawn up into the bulb and squirted around the inside of the hole to give it a slight rinsing and remove some of the larvae that might be left stranded. This water was again collected and returned to the sample. The rinsing was not sufficient to remove many of the eggs that might be adhering to the inside of the hole.

All water taken from the holes was placed in covered breeding dishes in the laboratory. Collections in which no larvae were present at the end of five days were discarded. All larvae obtained were bred out to the adult stage.

Each hole was examined 66 times. The bottle hole contained water at 32 examinations, and larvae were present in 30 of the collections. The total quantity of water taken from this hole was 6165 cc.

Water was collected from the basin hole 34 times, and all but two of the collections contained larvae. The total water removed from the hole amounted to 11,352 cc.

The following table gives the species of mosquitos, and the number of adults of each, that were bred out from the larvae collected from the two holes during 325 days :

Species of Mosquitos.	Bottle Hole.	Basin Hole.	Total.
	Number of adults.	Number of adults.	
Aëdes (*Stegomyia*) *apicoargenteus*, Theo. ...	167	394	561
Aëdes (*Stegomyia*) *aegypti*, Linn.	4	218	222
Aëdes (*Aëdimorphus*) *apicoannulatus*, Edw....	46	118	164
Aëdes (*Stegomyia*) *luteocephala*, Newst. ...	50	92	142
Aëdes (*Finlaya*) *longipalpis*, Grünb. ...	44	12	56
Cyathomyia fusca, Theo.	50	—	50
Aëdes (*Stegomyia*) *africanus*, Theo.	20	22	42
Aëdes (*Finlaya*) *wellmani*, Theo.	36	—	36
Aëdes (*Aëdimorphus*) *simulans*, N. & C. ...	10	19	29
Culex (*Culiciomyia*) *nebulosus*, Theo. ...	3	—	3
Totals	430	875	1,305

Mosquito Breeding in Crab-holes.

The large number of crab-holes along the margins of the lagoon in the vicinity of Lagos, Nigeria, prompted the writer to carry out an investigation regarding their importance as a breeding place for the yellow fever mosquito, *Aëdes* (*Stegomyia*) *aegypti*, Linn. This investigation was carried on at intervals throughout the period from 11th August to 5th November 1926. During this time collections of water, and mosquito larvae when present, were taken from 200 crab-holes in Lagos and Ebute Metta.

At the beginning of this work the holes were dug out and the water removed with a piece of glass tubing and a suction bulb. Since it was sometimes necessary to dig a distance of more than four feet in order to reach the pocket of water at the bottom of a hole, this method was found to involve a considerable amount of labour. It also frequently happened that while digging out a hole some of the loose earth would fall into the pocket of water with the result that we were unable to collect the sample.

After a number of holes had been dug out it was decided to try another means of obtaining the samples. An automobile pump, with the diaphragm reversed, and the lower valve removed, connected to a large suction bottle having a long piece of

rubber tubing attached was arranged, after a plan submitted by Dr. Allan M. Walcott, a member of this Commission. This apparatus proved to be quite satisfactory for pumping out the water without the necessity of digging. In using this apparatus the water from the hole was first pumped into the suction bottle and then transferred to other bottles. The suction bottle and rubber tubing were washed well with clean water after each sample was collected.

Naturally, it cannot be assumed that all the larvae in a hole would be removed either by means of the pump or by digging, since it is quite likely that some of the larvae sank into the soft mud at the bottom of the water pocket and remained there. The number collected, however, was sufficient to permit a very fair estimate to be made of the amount of breeding occurring and the species of mosquitos selecting the crab-holes as a place of oviposition.

The quantity of water obtained from a hole varied from 1 to more than 120 ounces. A few of the holes contained more than 120 ounces, but since this was the maximum quantity desired for a sample, all the water present was not taken when more was found. The total collections from the 200 holes amounted to 58·8 gallons.

Mosquito larvae were found in 113, or 56·5 per cent., of the holes, and 4,356 adults were bred out. The occurrence of the various species and the number of adults reared are shown in the following table :—

Species and Number of Adult Mosquitos bred from Larvae collected from 200 *Crab-holes.*

Species.	Number of of holes.	Percentage of holes.	Number of of adults.
Aëdes (*Aëdimorphus*) *irritans*, Theo.... ...	64	32·0	715
Uranotaenia annulata, Theo.	47	23·5	621
Culex (*Culiciomyia*) *cinerellus*, Edw. ...	28	14·0	2,012
Culex insignis, Carter	27	13·5	730
Aëdes (*Aëdimorphus*) *nigricephalus*, Theo. ...	11	5·5	160
Anopheles gambiae, Giles	8	4·0	26
Culex decens, Theo.	4	2·0	45
Culex pruina, Theo.	3	1·5	20
Aëdes (*Stegomyia*) *aegypti*, Linn.	3	1·5	10
Culex fatigans, Wied.	1	0·5	17
		Total	4,356

The largest number of adults to emerge from one sample was 562, consisting of 464 *C. cinerellus* and 98 *C. insignis*. The second in abundance was 556, which included 429 *C. cinerellus*, 50 *A. irritans*, 47 *C. insignis*, 22 *U. annulata* and 8 *C pruina*.

It may be noted from the foregoing table that *A. aegypti* was found in only three of the holes. One of these, at Ebute Metta, was situated 45 yards from the nearest habitation, and only two yards from the edge of the lagoon. Eight adult *A. aegypti* were bred from this sample and no other species was present. The second, which was also at Ebute Metta, and only three yards distant from the previous one, yielded 1 *A. aegypti* and 3 *U. annulata*. The third was in Lagos and was situated 15 yards from a habitation and 20 yards from the margin of the lagoon. The larvae taken from this hole produced 46 *C. insignis*, 15 *U. annulata*, 2 *A. nigricephalus* and 1 *A. aegypti*.

One hundred and twelve of the holes from which larvae were collected were not more than 100 yards from habitations, the remaining hole being 200 yards distant.

The finding of *A. aegypti* larvae in these three crab-holes demonstrated that, in Nigeria at least, this species does occasionally breed in collections of water where at the water's edge there is nothing but mud. This is somewhat at variance with some of the opinions in regard to the breeding habits of this species in the Americas.

Owing to the small number of *A. aegypti* found during this investigation it is perhaps justifiable to believe that crab-holes produce but few adults of this species and have but little importance in relation to yellow fever control. This view, however, is based only upon the results obtained from work carried out in Lagos by the writer and during only one season of the year. It is possible that observations in other localities, or at other seasons, might result in findings that would call for modification of this belief.

INVESTIGATIONS ON THE CONTROL OF THE KHAPRA BEETLE, (*TROGODERMA GRANARIUM*, EVERTS) WITH CALCIUM CYANIDE.

By Herbert W. Miles, M.Sc., N.D.A.,

Victoria University, Manchester.

The khapra beetle, *Trogoderma granarium*, Everts 1898, has been referred to in recent years as *Trogoderma khapra*, Arrow, and *Attagenus undulatus*, Mot. Investigations on the pest have been carried out by Barnes & Grove (1) in India, and by Dendy & Elkington (2), Mason (3), Parker & Long (4), and Morison (5) in England.

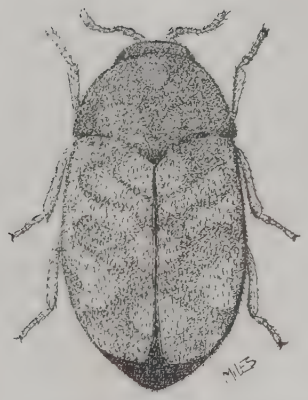


Fig. 1. *Trogoderma granarium*, Everts × 17.

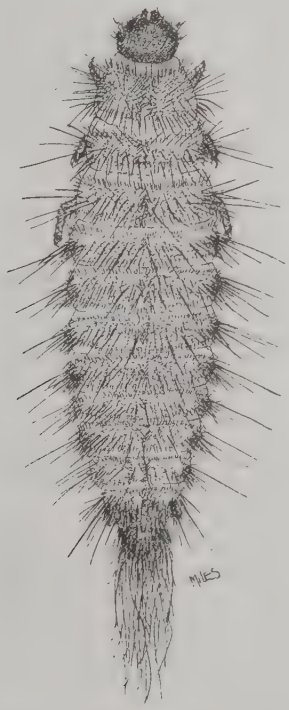


Fig. 2. *T. granarium*, larva × 17.

The most exhaustive work on the khapra beetle is that carried out by Voelkel (6) in Germany. This investigator gives a full account of the life-history of the pest and a detailed description of the different stages; he also includes an account of experiments on control by means of trapping and fumigation, and concludes that, as with other pests of stored products, the use of toxic gases promises the best results. In his experiments Voelkel used hydrocyanic acid gas, chlorpicrin and tetrachlorethane, all of which proved toxic to both adults and larvae.

During the Great War large quantities of Indian barley were shipped to the British Isles and this grain appears to have been infested with various stages of the khapra beetle. When the barley passed through the early processes in the making of malt, little notice was taken of the presence of the insect; but later it was found that the malt in the storage bins was infested with the pest, which had developed rapidly in the higher temperatures of the bins, whereas little development had taken place in the barley stores. Arrow (7) in 1917 evidently thought that it was not likely that the khapra beetle would become established as a pest in England, presumably because of the adverse temperature conditions; but apparently the infestation of the malt bins, which offer to the insect highly suitable conditions for rapid development had not been foreseen.

A considerable number of malt bins are now infested with khapra, and although little Indian barley is used, the pest still breeds in the malt bins and is responsible for an annual loss to the maltsters. Towards the end of the war and for a few years after, chlorpicrin, which was comparatively cheap and easily available, was used for malt bin fumigation. Though this treatment afforded great relief, the pest was not eradicated; and owing to the lack of further supplies of this gas, little control treatment has been carried out during the last three or four years, with the result that the pest has been increasing without any other check than that occasioned by the thorough cleaning of the bins in the summer when the last malt is drawn off. Such cleaning is only superficial, for though all dust, cast khapra skins and other débris are swept from the ceilings, walls and floors, the immature larvae are not removed from the deeper crevices.

Laboratory Experiments with Calcium Cyanide.

In order to determine whether hydrocyanic acid gas derived from calcium cyanide would prove toxic to the larvae of khapra beetles, an air-tight fumigating chamber was constructed. This glass and wood chamber had a cubic capacity of 5½ cubic feet, and was placed on a bench in the laboratory. Khapra larvae were placed in a glass basin on the floor of the chamber and provided with corrugated paper, in the folds of which they quickly secreted themselves. A wet and dry bulb thermometer was also introduced into the chamber, and the calcium cyanide was placed as evenly as possible on the floor round the basin. Fumigations were conducted with a temperature range of 67–72° F., and a relative humidity of 76–85 per cent., and exposures varying from 19½ to 24 hours. The calcium cyanide used throughout the experiments was "Cyanogas" brand, "G" grade, guaranteed to contain 40 to 50 per cent. pure calcium cyanide. The initial dosage was 10 oz. per 1,000 cubic feet and resulted in 13·8 per cent. kill. The dosage was then increased to 15 oz. per 1,000 cubic feet, and following this fumigation all the larvae were inactive next day, but numbers gradually revived. Fourteen days after the fumigation 45·45 per cent. were dead, 31·9 per cent. had recovered, and the remaining 22·72 per cent. were classed as doubtful.

Since all the larvae appeared lifeless for some time after fumigation with calcium cyanide at the rate of 15 oz. per 1,000 cubic feet, a dosage of 12½ oz. per 1,000 cubic feet was used in several fumigations, the humidity being increased to 85 per cent., since there was an indication that with higher humidity a greater kill might be obtained. The results from the fumigations indicated a kill of 88–92 per cent. after an exposure of 19–24 hours.

Upon examination immediately after exposure to the hydrocyanic acid gas the larvae used in these experiments were inactive and apparently lifeless. Within an hour or so odd specimens became active and when placed near food readily resumed

feeding. In the course of a day or two larvae which had been killed by the gas were easily distinguished because of shrivelling and discolouration. The remainder appeared healthy but incapable of movement. In from three to six days those larvae which had not received a toxic dose usually recovered, but occasional specimens recovered after as long as from 14 to 26 days. With larvae which had received a toxic dose this prolonged state of inactivity gradually merged into death.

The state of inactivity and apparent lifelessness of the larvae after fumigation is interesting, and two explanations are offered. It may be that the larvae can pass into a resting state similar to that produced by lack of oxygen (1), in which they remain healthy for a considerable time. The second explanation is that the hydrocyanic acid gas induces paralysis of the nervous system of the khapra larvae, as it is known to do with other insects. The larvae are to all intents and purposes healthy, but incapable of movement. Raising the temperature produced traces of movement after a few days, and in some cases movements were produced for the first time fourteen days after fumigation, and the larvae finally recovered and resumed feeding. Where fumigation is sufficiently strong and prolonged, the coma gradually merges into death.

In the first part of the accompanying table a summary is given of the data obtained from the laboratory fumigations.

Malt Bin Fumigations.

Based on the results of the laboratory experiments, three fumigations, commencing in September 1926, were conducted in commercial malt bins. The bins were approximately square with a capacity of about 5,000 cubic feet. Each had two walls faced with pitch, and two walls of woodwork which gave the pest access to the adjoining bins through cracks and spaces between the boards. Before fumigating all these cracks were carefully pasted over with thick brown paper.

The initial dose of calcium cyanide was 1 lb. per 1,000 cubic feet, but the dosage was subsequently increased to 1¼ lb. and finally to 2 lb. per 1,000 cubic feet as the temperature and relative humidity of the bins decreased. The fumigations were commenced about mid-day and the bins sealed up until about a week later, when they were thoroughly ventilated before being entered to examine the results and collect larvae.

The temperatures during the period occupied by the fumigations varied from 69° F. to 58° F., and the relative humidity from 69 per cent. to 61 per cent. Though these temperatures have proved satisfactory for glasshouse fumigation, with such low relative humidity as persisted in the malt bins the rate of evolution of hydrogenic cyanide is so slow as to render it difficult to obtain a concentration of hydrocyanic acid gas for a sufficient length of time to prove fatal to khapra larvae other than those exposed on the surface of the walls or in shallow crevices. This difficulty is reflected in the figures indicating the percentage of larvae killed. When the first fumigation was conducted conditions of temperature and relative humidity were at their best and the majority of larvae were in superficial positions or shallow crevices. Though the dosage was increased, subsequent fumigations yielded lower percentages of larvae killed. After the second fumigation larvae at the surface were difficult to find, but 46 were collected and all were dead. At the time of the third fumigation practically all the larvae were found in deep crevices, some over ten inches below the surface.

The gradual decrease in the numbers of larvae in surface crevices was due to two causes: the killing of many with the hydrocyanic acid gas, and the penetration of the remainder into deep crevices and fissures in the walls.

In the second part of the accompanying table a summary of the bin fumigations is given. When the conditions were most satisfactory 95 per cent. kill of the exposed larvae was obtained, which compares very favourably with the results obtained in the laboratory. With less favourable conditions, even though the dosage was increased, only 68·8 per cent. and 48 per cent. kills were obtained, the position of the larvae in the wall crevices undoubtedly influencing these results.

Conclusions and Recommendations.

Calcium cyanide can be used as a fumigant for the destruction of khapra beetles in malt bins, and at a dosage of 2 lb. per 1,000 cubic feet will give over 90 per cent. kill of exposed larvae, and a fair control of the more deeply secreted insects. The most successful results will probably be secured when several fumigations are carried out in summer as soon as possible after the malt has been drawn off. The bins should be made as air-tight as possible, and the calcium cyanide scattered evenly over the floors, the bins being finally closed and left for about a week before ventilating. Owing to the small man-holes, often in the ceilings, and inadequate ventilation and light in the older type of malt bin, the fumigation should be carried out under the supervision of a skilled and responsible fumigator, when, if used as described herein, calcium cyanide will be found to give a very satisfactory control of both adults and immature stages of the khapra beetle.

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Summary of Fumigations for the Control of Khapra Beetle.

1. *Laboratory Tests.*

Expt. No.	Date.	Dosage per 1,000 cu. ft.	Commencement of Fumigation.		Period of Fumigation.	Conclusion of Fumigation.		Date of final examination.	Dead.	Alive.	Total.	Kill.	Remarks.
			Temperature.	Humidity.		Temperature.	Humidity.						
		oz.		Per cent.	Hours.		Per cent.					P. ct.	
1	10.viii.26	10	68° F.	76	19½	67° F.	80	12.viii.26	5	31	36	13·88	Recovery apparent within 2 days.
2	11.viii.26	15	67° F.	76	20	68° F.	76	8.ix.26	14	8	22	63·63	Recovery not apparent within 3 days, noted after 14 and 26 days.
3	12.viii.26	12½	67° F.	80	19	67° F.	80	8.ix.26	34	2	36	88·8	Recovery not apparent within 2–3 days.
4	23.viii.26	12½	67° F.	80	22	72° F.	82	3.ix.26	14	2	16	87·5	
5	26.viii.26	12½	68° F.	85	24	66° F.	85	6.ix.26	26	2	28	92·8	
6	1.ix.26	16	67° F.	80	24	66° F.	83	9.ix.26	27	1	28	96·4	Greater proportion of young larvae in this batch and these show signs of death quicker than other specimens.

2. *Fumigation of Bins.*

Expt. No.	Date.	Dosage per 1,000 cu. ft.	Commencement of Fumigation.		Period of Exposure.	Conclusion of Fumigation.		Date of final examination.	Dead.	Alive.	Total.	Kill.	Remarks.
			Temperature.	Rel. Humidity.		Temperature.	Rel. Humidity.						
		lb.		Per cent.	Days.		Per cent.					P. ct.	
1	7.ix.26	1	69° F.	69	6	68° F.	72	28.ix.26	211	10	221	95	Majority of larvae from superficial crevices, etc.
2	5.x.26	1¼	69° F.	61	7	69° F.	61	19.x.26	199	90	289	68·8	Superficial larvae (46) collected separately, all dead.
3	10.xi.26	2	58° F.	63	7	51° F.	63	24.xi.26	36	39	75	48	Few superficial larvae to be found. Majority of larvae in deeper cracks and crevices.

NEW INJURIOUS CURCULIONIDAE (COL.).

By Guy A. K. Marshall, C.M.G., D.Sc., F.R.S.

Subfamily Otiorrhynchinae.

Blosyrus aequalis, Har. 1879.

This species, originally described from Angola, has recently been bred from larvae found in tubers of sweet potatoes at Haut-Lepori, Belgian Congo, by Lieut. J. Ghesquière.

Blosyrus haroldi, Hartm. 1904.

This weevil was also bred from sweet potatoes by Lieut. Ghesquière in company with the preceding species. I am unable to separate his specimens specifically from those from Tanganyika Territory, though it is unusual for species of this wingless genus to range across Africa. A variety of *B. haroldi*, however, occurs also in Uganda.

I recently described another *Blosyrus* that had been bred from sweet potatoes in South Africa, *B. batatae* (Bull. Ent. Res., xvii, 1926, p. 199), so that three species of the genus are now known to attack this plant.

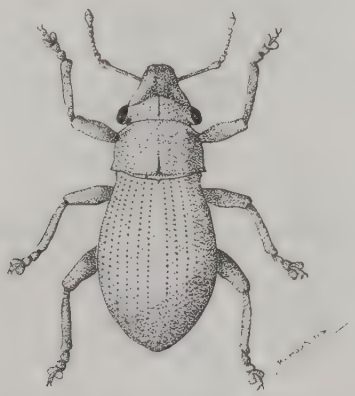

Fig. 1. *Protostrophus perspicax*, sp. n.

Protostrophus perspicax, sp. n. (fig. 1).

♀. Derm black, with dense sand-grey scaling, usually with a slight coppery reflection ; the pronotum with an indefinite broad lateral darker stripe ; the elytra with the inflexed margins paler, the dorsum usually almost uniform, but often with indefinite darker spots or stripes along the striae.

Head with the anterior transverse furrow deeply curved ; the forehead flat, with dense scaling and recumbent clavate setae, the median furrow narrow and deep ; the eyes much produced backwards, reaching the prothorax, strongly convex, and deepest far behind the middle. *Rostrum* shorter than its basal width, markedly sinuate at the sides, with the apex only a little wider than half the base ; the dorsum with a shallow median impression and a low squamose median carina in the basal half, and the lateral areas sloping outwards. *Antennae* black, with dense grey scaling, and the club reddish brown ; the funicle with joint 1 twice as long as 2, 3–6 subequal and about as long as broad, 7 a little longer and broader. *Prothorax* transverse (14 : 9), with the basal margin slightly arcuate in the middle and deeply sinuate on

each side, with the basal angle sharply projecting ; the sides gradually narrowing from base to apex and rounded or obtusely angulated about the middle ; the apical lateral angles excavated for the reception of the eyes, the excavation being bounded behind by a vertical carina ; the apical margin gently arcuate and not sinuate in the middle; the dorsum strongly convex transversely, quite even, with an abbreviated median furrow in the basal half that does not reach the base and a shallow transverse impressed line close to the base ; the scales small, rounded and closely placed, the setae clavate and appressed. *Elytra* ovate, strongly rounded at the sides, widest slightly behind the middle, obtusely acuminate at the apex ; the base shallowly sinuate, the lateral angles forming a small obliquely-projecting process that fits into the basal sinuation of the prothorax ; the shallow striae partly obscured by the scaling, the three juxta-sutural ones curving outwards at the base ; the punctures (when the scaling is intact) small but distinct, each containing a minute seta ; the intervals flat or feebly convex, with irregular spatulate recumbent setae ; the scales like those on the pronotum but slightly smaller. *Legs* with uniform dense coppery-grey scaling ; the front tibiae with an apical row of small closely-set spines, the hind corbels narrowly enclosed and spinose externally, and bare inside.

Length, 4·5 mm. ; breadth, 2·0 mm.

Transvaal : Rietbokspruit, 8♀♀, 28.xii.1926.

Reported by the Division of Entomology, Pretoria, as defoliating citrus trees.

Nearly allied to *P. ocularius*, Mshl. 1927, which differs, *inter alia*, in having the antennae red-brown ; the eyes are much more produced ; the prothorax has a low median carina and the posterior angles are much more deeply sinuate, so that the basal angles of the elytra do not fit into them ; and the setae on the elytra are in regular rows.

Orthomias edax, sp. n. (fig. 2).

♂♀. Derm black, with dense pale brown scaling (usually with a slight coppery reflection), more or less variegated with greyish white ; the prothorax with two broad ill-defined whitish stripes on each side, one in a line with intervals 3 and 4 of the elytra and the other with ints. 8 and 9 ; the elytra with ints. 3 and 4, and also 7 and 8, more or less sprinkled with whitish scales (especially towards the base), forming sometimes the appearance of faint greyish stripes ; ints. 9 and 10 (like the underside) with the scaling of a more fulvous tint.

Head not very strongly convex transversely ; the eyes moderately prominent. *Rostrum* somewhat longer than broad, gradually narrowing from the base to beyond the middle, then widening slightly to the apex, with a fine median furrow continuous with that on the head and a somewhat oblique longitudinal impression on each side which is bounded internally by a low costa ; the lateral margin of the dorsum rounded off and not carinate, and the apical area broadly but shallowly depressed ; the ante-ocular space subcarinulate, but not impressed. *Antennae* with the scape short, gradually clavate and squamose ; the funicle with joint 1 nearly as long as 2+3+4, 2 much longer than broad, 3–6 subequal and moniliform, 7 conical and slightly broader than long. *Prothorax* a little broader than long, rounded at the sides (rather more so in ♂), widest at the middle, deeply constricted just before the base and more shallowly near the apex, truncate at both base and apex, the former being the broader and distinctly carinate ; the dorsum rugosely granulate, with a narrow median sulcus that reaches neither base nor apex; the scales on the granules arranged more or less stellately round a very short subrecumbent spatulate seta. *Scutellum* small but distinct. *Elytra* subelliptical or obovate, at their widest much wider than the thorax, widest at (♀) or a little behind the middle (♂), without any subapical constriction, but shallowly constricted at the base, with the basal margin

raised and the lateral angles slightly projecting; the striae deep and containing coarse punctures, which gradually disappear towards the apex and which are quite covered with scales, their position being marked by a minute seta; the intervals convex, broader than the striae, indefinitely granulose, and each bearing a row of numerous short curved spatulate pale setae. *Legs* with dense variegated scales; all the tibiae sharply denticulate on the inner face at least on the apical half, the corbels of the hind pair squamose inside.

Length, 5·4–6·6 mm.; breadth, 2·3–2·7 mm.

Transvaal: Louis Trichardt, 4♂♂, 6♀♀, xii.1926 (*T. C. Cairns*).

The genotype, *O. seriatus*, Fst. 1885, which also occurs in the Transvaal and which I know from description only, is a much larger insect (9 mm.) and has four fine carinae on the rostrum and a lateral triangular impression in front of the eyes; joint 2 of the funicle is as long as broad; and in the ♂ the elytra at their widest are somewhat narrower than the prothorax.

The present species is very similar in general facies to *Piazomias varicolor*, Mshl. 1907, but the latter may be readily distinguished by the long pointed erect setae on the elytra and the much flatter eyes.

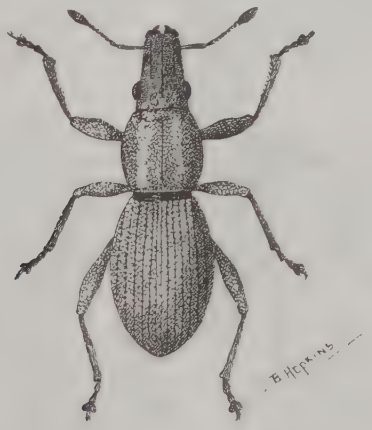

Fig. 2. *Orthomias edax*, sp. n.

O. edax is reported by the Division of Entomology, Pretoria, as damaging cotton plants.

Piazomias varicolor and *P. pratensis*, Mshl. 1907, must be transferred to the genus *Orthomias*, Fst. 1885; whereas *P. deceptor*, Mshl. 1907, belongs to *Xenorrhinus*, Fst. 1886.

In the figure the rostrum has been shown diagrammatically as in a horizontal position, which makes it appear longer than it really is; actually it is strongly deflected.

Isaniris pusillus, Hustache, 1923.

The adults of this species have been reported as attacking the leaves of coffee in Uganda. The localities from which the insect is known are as follows:—

Belgian Congo: Albertville, xii.1918 (*R. Mayné*). Uganda: Bugoma Forest, Unyoro, 3,700 ft., xii.1911 (*S. A. Neave*); Hoima, 25.x.1922 (*H. Hargreaves*).

Systates perblandus, sp. n. (fig. 3).

♂♀. Derm black, with dense pale metallic green scaling, interrupted by shiny flattened black granules on the prothorax and by larger raised black patches on the elytra, forming a regular tessellated pattern ; the underside fairly densely squamose on the sternum, but more sparsely on the venter, the terminal ventrite of the ♀ being bare.

Head separated from the rostrum by a straight (♂) or slightly curved furrow (♀), flattened dorsally, with very shallow and obliquely confluent punctures (normally hidden by scaling) and with a shallow median furrow in the anterior half which becomes merely a bare smooth stripe behind ; the eyes moderately convex, highest about the middle. *Rostrum* longer than broad, subparallel-sided in the basal half and moderately dilated at the apex ; the dorsal area in quite the same plane as the forehead, almost flat, with shallow obliquely confluent punctures and a strong bare

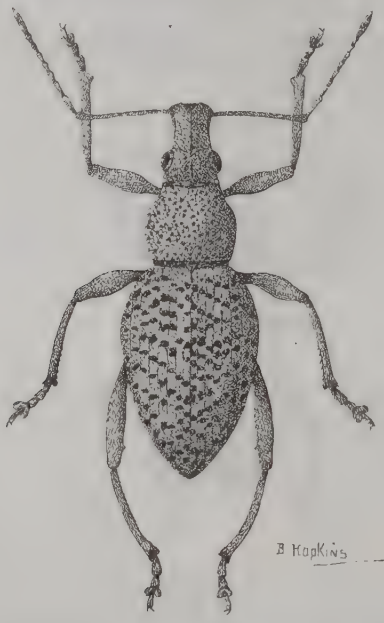

Fig. 3. *Systates perblandus*, sp. n.

median carina terminating before the apex in a low bare transverse callus, the lateral margins obtusely angulated but not carinate ; the interantennal area horizontal, flat and shallowly punctate ; the lateral areas not definitely costate or sulcate, rugulose. *Antennae* with the scape slender, cylindrical, straight, gradually clavate at the apex, and sparsely clothed with hair-like green scales and recumbent setae ; the joints of the funicle in order of length : 1, 2, 3, 5, (4, 7), 6. *Prothorax* somewhat transverse, moderately rounded at the sides, widest at the middle, with a broad shallow constriction at the apex, and truncate at base and apex, the latter being the narrower ; the dorsum gently convex longitudinally, highest behind the middle, not very closely set with low flattened granules that are mostly transverse and bear a short recumbent seta. *Elytra* narrowly ovate in ♂, much broader and more sharply acuminate in ♀, widest well before the middle, steeply declivous at the base but not actually truncate, the apex produced and visible from above, the tip being curved downwards like

a beak in the ♀ only ; the narrow striae with numerous punctures that do not disappear towards the apex, but are for the most part hidden by the scaling ; the intervals much broader than the striae in both sexes, slightly convex, and each with a row of shiny raised patches, which often occupy the whole width of the interval and link up with those on other intervals to form wavy bare bands ; each raised patch bearing a short curved spatulate pale seta ; the scales convex and nearly circular. *Legs* with moderately dense green scales and spatulate pale setae ; the anterior pairs of tibiae with a row of spiniferous granules on the lower edge ; the hind pair of the ♂ curved, somewhat flattened on the inner face and with irregular low granules, but without long hairs, and the lower edge with a row of more conspicuous rounded granules ; the hind tibiae of the ♀ very similar, but rather less curved and with smaller granules ; the hind femora of the ♂ with an obtuse tooth on the *inner* face not far from the apex.

Length, 6·3–7·8 mm. ; breadth, 2·4–3·7 mm.

Nyasaland : Mt. Mlanje, 20♂♂, 18♀♀, iv.–vi.1913, 1♂, ix.1913, 1♂, xii.1913 (*S. A. Neave*—type) ; Ruo Valley, 2,000 ft., 1♂, xii.1913 (*Neave*) ; Mt. Mlanje, 2♂♂, 1♀, ii.1927 (*C. Smee*) ; 1♂, 5♀♀, Cholo (*R. C. Wood*). Portuguese E. Africa : Kola R., E. of Mt. Chiperone, 1♀, iv.1913 (*Neave*).

A very distinct species, readily recognisable by its tessellated green and black elytra, and the subapical tooth on the inner face of the femora in the male.

Reported by Mr. C. Smee, Government Entomologist, as injurious to maize.

Systates smeei, sp. n. (fig 4).

♂♀. Derm black, moderately shiny, almost bare ; the upper surface sparsely scattered with small white or greenish white scales, these being more numerous about the shoulders of the elytra and also forming a definite small patch of 12–30 scales at the base of interval 3 ; the lower surface also very sparsely squamose, but with denser patches on the anterior lateral angle of the mesepisterna, on the mesepimera, on the posterior lateral angles of the metasternum, and on and in front of the two anterior pairs of coxae.

Head separated from the rostrum by a straight furrow, with large shallow punctures (sometimes confluent) and a deep median sulcus ; the eyes moderately convex, highest at the middle. *Rostrum* similar in the two sexes, a little longer than broad, slightly narrowed for a very short distance from the base and then regularly widening to the apex ; the dorsal area parallel-sided, with a low shiny median carina, which is more or less widely and indistinctly forked at three-fourths from the base, and on each side of it a broad shallow depression containing coarse shallow confluent punctation, the subcostate margins being more sparsely punctate ; the interantennal area almost horizontal, shallowly impressed, and with variable indefinite punctation ; the lateral areas with a low costa between the scrobe and the eye, and a broad shallow furrow above it. *Antennae* black ; the scape slender, gradually clavate, and thinly clothed with fine recumbent setae ; the joints of the funicle in order of length : 1, 2, 3, (4, 5, 7), 6. *Prothorax* nearly as long as broad (♂) or somewhat broader (♀), strongly rounded at the sides, widest a little behind the middle ; the base truncate and marginate, slightly broader than the apex, which is truncate or occasionally sinuate in the middle ; the dorsum closely and evenly set with large flattened shiny granules, each bearing a minute recumbent spatulate seta. *Elytra* narrowly ovate and obtusely acuminate behind in ♂, much broader and less acuminate in ♀, widest well before the middle, very steeply declivous at the base, but not actually truncate, the apex not visible directly from above owing to the lower part of the declivity being perpendicular ; the shallow striae containing large subquadrate punctures that become almost obsolete behind the middle, the septa between the punctures

subgranulate (especially in ♂); the intervals as broad as (♂) or broader than the striae (♀), with rather irregular rows of flattened granules (more marked in ♂) which tend to form transverse rugae in the basal half; int. 10 and the apical half of 9 (♂) or ints. 10 and 9 and the apical half of 8 (♀) without granules; the setae minute, spatulate and recumbent. *Legs* thinly clothed with narrow greenish or white scales; the femora finely and unevenly strigulose and with a few punctures; the tibiae rugosely punctate, the two anterior pairs not granulate, the hind pair almost similar in the two sexes, scarcely curved, with a row of coarse granules on the inner face and a row of finer ones on the lower edge, and without special setae in ♂.

Length, 5·4–7·8 mm.; breadth, 2·4–3·6 mm.

Fig. 4. *Systates smeei*, sp. n.

NYASALAND: Mt. Mlanje, 30♂♂, 28♀♀, 1.–vii.1913, 2♂♂, 2♀♀, ii.1914 (*S. A. Neave*), 3♂♂, 2♀♀, iv.1927 (*C. Smee*). PORTUGUESE E. AFRICA: Kola R., E. of Mt. Chiperone, 1♂, 1♀, iv.1913 (*Neave*).

Allied to *S. crenatipennis*, Fairm. 1887, which differs *inter alia*, in having the rostrum markedly tricarinate; the prothorax is widest at the middle; the elytra are more oblong-ovate and less acuminate behind, and the granules are much smaller and mostly indistinct, being more noticeable at the base and apex; the hind tibiae are not granulate, and those of the ♂ are deeply sinuate internally on the apical half and fringed with long setae.

This species is reported by Mr. Smee as attacking the leaves of tea.

Tanyremnus, gen. nov.

Head globular ; the forehead continuous with the rostrum and narrower than its base ; the eyes not more convex than the head. *Rostrum* elongate, moderately slender, with an indefinite triangular epistomal area ; the scrobes dorsal, beginning close to the apex and ending indefinitely not far from the eyes ; the mandibles strongly overlapping, with a single apical tooth and a distinct scar ; the submentum with a peduncle and behind it two long suberect setae ; the mentum as wide as the buccal opening in front, but narrowing behind and without setae. *Antennae* long and slender, the scape somewhat exceeding the eye, and joint 1 of the funicle longer than 2. *Prothorax* with the postocular lobes feeble. *Legs* elongate, the femora dentate ; the first tarsal joint as long as 2+3 and much broader than 2, the claws free.

Genotype, *Tanyrrhynchus loripes,* Boh.

This genus is in many ways intermediate between *Tanyrrhynchus* and *Eremnus.* With the former it agrees in its general facies, the elongate rostrum and broad first tarsal joint ; but the structure of the rostrum, and especially the mandibles, indicate that it is better placed in the EREMNINI. In typical *Tanyrrhynchus* the lower surface of the rostrum is laterally compressed, bare and shiny ; there is no epistomal area ; the mandibles do not overlap and have no true scar ; the antennae are inserted at some distance from the apex ; and the two long setae on the submentum are wanting.

From *Eremnus* this genus differs in its elongate rostrum, the distinct peduncle to the submentum, and the large first tarsal joint.

Tanyrrhynchus loripes, Boh.

Six males of this species from Port Elizabeth, Cape Province, 25.i.1927, have been forwarded by the Division of Entomology, Pretoria, with the information that the adults have been found attacking *Pinus pinaster.*

Subfamily GONIPTERINAE.

Gonipterus platensis, Marelli, 1926.

In a recent paper (Bull. Ent. Res. xvii, 1927, p. 215) I stated that this insect was only an immature form of *G. gibberus,* Boisd. ; but since then Dr. C. A. Marelli has kindly sent me a number of specimens, and from an examination of the male genitalia I am satisfied that *G. platensis* is a distinct species. It is possible, however, that it may have already been described from Australia.

Subfamily NANOPHYINAE.

Nanophyes terminaliae, sp. n.

♂♀. Pale testaceous yellow, the apex of the rostrum, the antennal club, and the last two joints of the tarsi, fuscous, and the basal margins of the pronotum and elytra black ; the median area of the pronotum broadly clothed with sparse recumbent blackish setae (enclosing a median stripe of pale hairs on the basal half), the patch having a deep sinuation on each side at about the middle, and the sides with similar yellow setae ; the elytra also with yellow setae, which are replaced by finer dark setae on the following areas : on interval 1 from one-fourth from the base to three-fifths, on the basal fifth of int. 2 and again for a short distance at about the middle, on the basal sixth of int. 3, and on a large indefinite subquadrate patch on ints. 3–6 extending from the middle to about one-fifth from the base ; the sternum clothed with dense yellow squamiform setae.

Head forming a distinct low angle with the dorsal outline of the rostrum; the eyes practically contiguous, separated only by a line of suberect pale setae; the vertex with dark setae. *Rostrum* gently curved, a little shorter (♂, 8 : 9) or a little longer (♀, 10 : 9) than the head and pronotum; the antennae inserted beyond the middle in both sexes, the apical portion of the rostrum of the ♀ being nearly as long as the scape, and of the ♂ half as long; the dorsum tricarinate to the antennae, the sulci being shallowly punctate and conspicuously setose in the ♂, but not in the ♀; the apical area with four rows of punctures. *Antennae*: length of scape 0·65, funicle 0·40, club 0·40 mm.; the joints of the funicle in order of length: (1, 2) 3, 4, 5; joint 4 symmetrical, 5 slightly longer than broad. *Prothorax* with the sides quite straight and the base broadly arcuate, two-thirds as long as the basal width; the dorsum distinctly convex longitudinally, moderately shiny and finely aciculate. *Elytra* with the shoulders much reduced, the striae shallow, and the punctures almost obsolete. *Legs*: the femora with one large tooth, the front pair with four additional small ones (one rarely absent) and the posterior pairs with three (one rarely absent on the middle femora).

Length, 2·3–2·9 mm.; breadth, 1·2–1·5 mm.

N. MADRAS: Nedungayam, Nilambur, 3♂♂, 2♀♀, 6.iv.1927.

It is not quite certain that the specimens described are fully mature, and it is therefore possible that the real ground-colour may be testaceous brown.

Very closely allied to *N. andrewesi*, Fst. 1898, which has an almost identical pattern on the elytra but is a smaller insect (2 mm.) and has the darker parts clothed with brown hairs instead of black (Faust describes the dark parts erroneously as being bare). Moreover, in *N. andrewesi* the basal part of interval 2 bears white hairs and not black; the first joint of the funicle is longer than the second; the club of the antennae and the terminal joints of the tarsi are not dark, etc.

These weevils, which have been forwarded by Dr. C. F. C. Beeson, Forest Entomologist, breed in the fruits of a timber tree, *Terminalia paniculata*, and are at times so abundant as to make it difficult to obtain sufficient seed for planting purposes.

Subfamily CRYPTORRHYNCHINAE.

Conotrachelus phaseoli, sp. n.

♂. Head, rostrum and prothorax red-brown, with the propleurae blackish or piceous except near the apex; the elytra yellow-brown, with a very variable, irregular, blackish or piceous, oblique band from behind the shoulder to the middle of stria 1, and a similar indefinite transverse band across the declivity, with some ill-defined dark patches between the two bands, all the dark areas being bare and the light areas rather thinly clothed with pale yellowish scales; the pronotum on each side with a broad stripe of dense yellowish scales from the base to two-thirds or three-fourths, and a shorter narrower stripe outside of it; the legs red-brown, the femora blackish or piceous dorsally (except at base and apex) and usually with a patch of yellow scales on the larger tooth and a transverse dorsal patch of white scales above it, the tibiae generally darker on the basal half.

Head separated from the rostrum by a curved impression containing a deep median fovea, almost bare, closely punctate, the punctures becoming rugosely confluent on the shallowly impressed forehead; a deep sulcus along the upper margin of each eye. *Rostrum* a little longer than the head and pronotum, stout, moderately curved, parallel-sided to the apex, with a high narrow carina from the base to beyond the middle and two low sinuous carinae on each side of it; the antennae inserted at one-fourth from the apex; the apical area with close, longitudinally confluent punctures. *Antennae* with the funicular joints comparatively short, joint 1 a little longer and much thicker than 2, 3 and 4 subequal and longer than broad, 5 about

as long as broad, 6 and 7 transverse ; the club broadly ovate, much broader than the funicle. *Prothorax* only slightly broader than long (8 : 7), gently rounded at the sides, widest at about the middle, shallowly bisinuate at the base, distinctly narrower at the apex, the dorsal part being produced over the head and shallowly sinuate in the middle ; the dorsal profile gently convex, but slightly depressed in the apical third ; the dorsum with deep separated punctures, the intervals dull and shagreened, with an admedian pair of low granules beyond the middle ; an almost bare median stripe, which is feebly impressed at both base and apex, the remaining surface, apart from the lateral stripes, being thinly clothed with minute narrow scales and set with subrecumbent, feebly spatulate setae ; the pleurae coarsely punctate and devoid of scales, except for a small patch in front of the coxae. *Scutellum* narrowly ovate, bare and impunctate. *Elytra* much broader than the prothorax (12 : 7), with the shoulders roundly rectangular, slightly widening just behind them and then narrowing in a curve to the apex, which is jointly rounded, and with a deep ante-apical impression

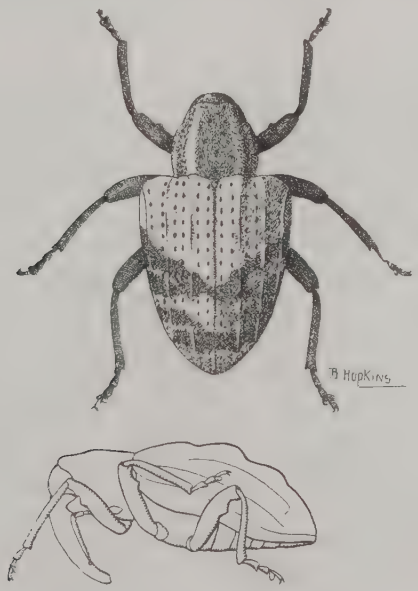

Fig. 5. *Conotrachelus phaseoli*, sp. n.

on each side of the declivity ; deeply seriate-punctate, with intervals 3, 5, 7, 9 broader than the others and sharply carmate, the carinae not reaching the base or the apex ; the carina on int. 3 broadly interrupted just before and again just behind the middle, that on 5 broadly interrupted further forward than that on 3 and with a small notch about the middle ; the odd-numbered intervals each with an irregular row of short stout erect setae ; the scales denser and broader above and behind the shoulders, in a stripe at the apex of interval 3, and in a patch at the apex of ints. 7–9. *Legs* coarsely and reticulately punctate; the femora with a single small tooth, which is continued to the apex in the form of a carina and there sometimes bears a trace of another very small tooth ; the tibiae hardly sinuate inwardly at the base ; the tarsal claws with a moderately long divergent tooth. *Underside* : the mesosternum flattened between the coxae and with its anterior edge slightly projecting and broadly arcuate ; the metasternum very strongly punctate and with a short longitudinal

elevation between the mid and hind coxae; the venter with a row of deep foveolae along the basal margin, the punctures elsewhere mostly shallow and indefinite, and the anal ventrite with a shallow transverse median impression at the apex and a small deep one on each side of it, the two raised areas between the impressions each bearing a single long erect seta.

Length, 2·4–3·5 mm.; breadth, 1·2–1·8 mm.

Brazil: Bahia, 5♂♂, 1927 (*Dr. G. Bondar*).

The nearest ally of this species is *C. stigmaticollis*, Fhs. 1837, which I know from description only and which differs in having the elytral carinae interrupted only in one place, namely, behind the middle on interval 3. It was described from Campos, Brazil.

Dr. Bondar records the present species as being injurious to haricot beans (*Phaseolus vulgaris*), the larvae boring in the stems.

Subfamily Baridinae.

Athesapeuta cyperi, sp. n.

♂♀. Derm shiny black, with the antennae, tibiae, and the lateral and apical margins of the elytra, sometimes red-brown; the prothorax with a broad lateral stripe of dense yellowish-white scales on each side (corresponding with the space between striae 5 and 8 on the elytra); the elytra with an irregular transverse band of whitish scales behind the middle between striae 1 and 5, an elongate patch at the base of interval 3 and a few scales at its apex, and isolated scales scattered along ints. 5 and 9; the underside with an isolated scale in each of the punctures, those on the sternum being broad and those on the venter narrow.

Head bare, finely alutaceous, and with sparse punctures. *Rostrum* about as long as the head and pronotum in the ♀, a little shorter in the ♂, strongly curved, smooth, with four rows of small punctures in addition to a punctate area above the scrobe, and a few scales on each side of the base. *Prothorax* about as long as broad, subparallel-sided from the base to the middle, then gradually narrowing to the tubular apical constriction; the base shallowly bisinuate, the apex truncate; the dorsum with strong shallow separated punctures and a broad impunctate median stripe; the punctures on the pleurae larger and subreticulate. *Scutellum* bare, transverse, and with two low longitudinal costae. *Elytra* oblong-ovate, but little wider than the prothorax, separately rounded at the apex; the deep striae indefinitely punctate and not diminishing at the apex; the intervals flat, broader than the striae, each with a row of large shallow punctures containing a recumbent seta; the setae small on ints. 1–5, larger and scale-like on the outer intervals; the scales oblong. *Pygidium* with coarse subreticulate punctation. *Legs* with separated elongate scales each lying in a puncture; the two anterior pairs of femora with a fringe of long setae on the lower face; the front tibiae of the ♂ with a stout sharp tooth on the inner edge at about the middle.

Length, 2·8–3·3 mm.; breadth, 1·3–1·5 mm.

Philippine Is.: Los Baños, 1♂, 2♀♀, iv.1922 (*F. X. Williams*). Hawaiian Is.: Honolulu, Oahu, 1♂, 1♀, viii.1927 (*O. H. Swezey*).

Much smaller than any of the previously described species and also distinguished by the median tooth on the front tibiae of the male. Its nearest ally is the Indian *A. affinis*, Fst. 1898, which, apart from its much larger size, has an additional band of scaling at the base of the elytra, and intervals 4 and 6 much narrower than 5 at the base, besides lacking the rows of large scale-like setae on the outer intervals.

The larvae of this species bore in the stems of "nut grass" (*Cyperus rotundus*) and have been introduced into Honolulu from the Philippines for the purpose of destroying this plant.

MOSQUITO NOTES.—VII.

By F. W. Edwards.

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I. The Varieties of *Anopheles mauritianus*, Grp.

The variation of *A. mauritianus* was discussed long ago by Alcock (Jl. Lond. Sch. Trop. Med., i, pp. 89–93, 1912), who concluded that the differences observed were due to mere individual variation. In my key to African *Anopheles* (Bull. Ent. Res., iii, p. 250, 1912) I suggested that an East and a West African form might be distinguished by the amount of white on the hind tibia and first tarsal segment. Careful study of more extensive material has shown that this generalisation cannot be maintained, but that there are four varieties of the species which can be rather easily distinguished, and fortunately the published names can be applied to them. Diagnoses of these varieties have been given by Miss A. M. Evans in her recently published guide to the African Anophelines (Memoir No. 3, New Series, Liverpool Sch. Trop. Med., Oct. 1927), but the definitions are somewhat expanded in the notes below, and a further account of the distribution is given. The variations are certainly of more than individual significance, because they show a distinct tendency to localisation, and bred series from one place do not exhibit much variation. On the other hand, I do not consider that there is more than one species, because no differences are apparent in the male hypopygium; I have mounted specimens of each of the four varieties and find them all to agree rather closely with Christophers' description and figure. In one point, however, Christophers' account seems to be at fault: the mesosome has always two or three pairs of distinct leaflets, the longest of which are nearly one-third as long as the tube.

Anopheles mauritianus, Grp., type form (=var. *similis*, Theo.).

Hind legs: Tibia with a long white patch at the tip above, quite four times as long as the tibial diameter; first tarsal with a white ring of similar length at base, and another not much narrower at the tip. Both the tibia and first tarsal segment usually have a cream-coloured line beneath. Second tarsal segment with the apical third or rather more white. Third tarsal segment with a black ring at the base. *Wings* with no pale fringe-spot on posterior margin. First costal spot very small, not extending on to the first vein. Pale fringe spot at tip of wing white, small, not extending below lower branch of upper fork. Third vein and branches of fourth mainly dark, but no dark scales on basal half of sixth vein. *Abdomen*: Scale-tuft on seventh abdominal sternite of female always distinct.

Distribution.—This is the only form of the species occurring in Madagascar and Mauritius, and is also represented in the British Museum from Natal, Transvaal, Zululand, Delagoa Bay, Rhodesia, Belgian Congo (Katanga Province), Uganda, and Kenya.

Several specimens from the Gold Coast (Kumasi, Sunyani and Bole) agree with the above definition except in the following points: The white spot at the tip of the first hind tarsal segment is much smaller; the second segment has almost the apical half white; and the third segment is entirely white. Another specimen from Uganda (Kasala, *Fraser*) is similar to these specimens from the Gold Coast, but has a narrow black ring at the base of the third hind tarsal segment.

Four females from Abyssinia (Berga River, Addis Allem, 7,500 ft., *H. Scott*) also agree with the type form except in the following points: First hind tarsal segment more extensively pale, the creamy ventral line extending to the sides and even to the dorsum on more than the basal half of the segment. White on tip of first two hind tarsal segments less extensive. Apical fringe-spot of wings still smaller or even absent.

Anopheles mauritianus var. **ziemanni,** Grünb.

This name may perhaps be used for the commonest West African form.

Hind legs: Tibia with a white patch at the tip above, which is not quite twice as long as the tibial diameter; first tarsal segment with a white ring of similar length at base. Neither tibia nor first tarsal segment distinctly pale beneath. First two tarsal segments narrowly white at the tip, third more than half white. *Wings* with no pale fringe-spot on posterior margin. First costal spot small or absent, not extending on to first vein. Pale fringe-spot at tip of wing yellow, large, reaching down to tip of third vein or beyond. Third vein extensively pale, also the branches of the fourth; no dark scales on basal half of sixth vein. *Abdomen*: Few or no scales on seventh sternite of female.

Distribution.—Specimens are in the British Museum from the following sources: Sierra Leone (Bap, Messina, Sama, *E. Hargreaves*). Gold Coast (Bole, *Ingram*; Accra, *Macfie*). Nigeria (Lagos, *Graham*). Belgian Congo (Lualaba River, 10° S., *Yale Massey*). Sudan (Bowan, *King*; Sobat, *Wenyon*). Nyasaland (*Daniels*). Tripoli (Misurata, *per G. Franchini*).

Specimens from Abyssinia (N.-W. shore of Lake Zwai, 5,500 ft., *H. Scott*) agree with the above definition of var. *ziemanni*, except that the apical fringe-spot is small, not extending below vein R_3.

Anopheles mauritianus var. **tenebrosus,** Dön.

Similar to var. *ziemanni*, but with less white on the hind legs; the apical tibial spot is not longer than broad; the first tarsal segment has few or no white scales at the base, the first and second being only narrowly white at the tip, and the third often more than half black.

Distribution.—Apparently this is the only form occurring in Egypt, judging from Kirkpatrick's description. Specimens in the British Museum are from Palestine (Kishon, *Barraud*). Egypt (Alexandria, *O'Connor*). Nyasaland (Cholo, *Wood*). Kenya (Nairobi, *Symes*). Orange Free State (Vaal River, *Ingram*).

Several of the specimens from Nyasaland have the second costal spot absent, but in the others it is distinct. The single female from Nairobi has the apical fringe-spot smaller than usual, almost as in the type form.

Anopheles mauritianus var. **paludis,** Theo.

Hind legs: Tibia with a very small creamy-white spot at the tip, which does not extend on to the tarsus. First two tarsal segments very narrowly white at the tip, last three all white. No distinct pale line beneath tibia or tarsus. *Wings* with a more or less distinct pale spot in fringe of posterior margin opposite end of lower

branch of fifth vein. First costal spot small, but usually distinct and extending on to the first vein. Second costal spot usually larger. Pale fringe-spot at tip large, extending down to tip of third vein. Third vein mainly dark, and at least a few dark scales present on basal half of sixth vein. *Abdomen*: Scale-tuft on seventh sternite always distinct.

Distribution.—British Museum specimens are from Sierra Leone (Katuna, *Christophers*; Sama, *E. Hargreaves*). Nigeria (Aboh, *R. W. Gray*). Belgian Congo (Coquilhatville and Lokolela, *Yale Massey*; Stanleyville, *Mouchet*; Elizabethville, *Schwetz*). Angola (*Wellman*). Tanganyika (Bukoba, *Ritchie*).

II. A new East African *Anopheles*.

Anopheles (Anopheles) symesi, sp. n.

A large dark species evidently closely allied to *A. mauritianus*, which it resembles in most respects, but differs strikingly from all varieties of *A. mauritianus* in the following respects:—

Integument of thorax less dark, especially the pleurae, which are a rather light brownish. No scales on seventh abdominal sternite. Front and middle legs almost entirely black, only faint traces of pale spots at the tarsal articulations. Hind tibiae with only a faint yellowish spot at the tip; hind tarsi with segments 1 and 2 all black, 3 black on the basal half, white on the apical half, 4 white, 5 black. Wings with the scales on the stem of the fifth vein (*Cu*) almost all yellow, only a few black ones in the middle (*A. mauritianus* in all its four or five varieties always has the basal half of the stem of the fifth vein black-scaled).

The palpi are rather less shaggy than in *A. mauritianus*, with small white rings at the base and tip of the terminal segment, and only a very few pale scales at the articulations of the other segments. Clypeus and prothoracic lobes with tufts of black scales as in *A. mauritianus*. Wings with the first costal spot yellowish white, very minute and not involving the first longitudinal vein. Second costal spot distinct and involving both branches of the upper fork, the spot on the lower branch (R_3) wider than in *A. mauritianus*, and its outer edge vertically below the outer edge of the costal spot, instead of much before it. Scales of third vein almost all yellow, those on stem of fourth vein all black; sixth vein yellow with a black spot in the middle and one at the tip. Fringe of hind margin entirely dark.

Kenya Colony: Kisumu, iii.1927, 2♀ (*C. B. Symes*).

The only other African *Anopheles* which has the fourth hind tarsal segment white and the fifth black is *A. kingi*, Chr., which might possibly be confused with the new species, although it is quite unrelated, the spotted femora and tibiae of *A. kingi* affording an obvious distinction. The absence of the scale-tuft on the seventh abdominal segment may not be constant over a series of specimens; its presence in *A. mauritianus* is not quite constant, as in the variety *tenebrosus*, Dön., it is very small and sometimes absent.

III. A new West African *Aëdes*.

Aëdes (Aëdimorphus) flavicollis, sp. n.

♂. *Head* clothed above with a large area of bright yellow scales, the close-lying ones narrow; scales at sides of head mostly flat and black. Clypeus dark brown, bare. First antennal segment dark brown, with a few small pale scales. Proboscis scarcely, if at all, longer than the front femora, black-scaled, with a narrow white ring in the middle, which is more distinct on the upper side. Palpi about nine-tenths as long as the proboscis, slender, without hairs except for three or four bristly ones

on the penultimate segment; scales mostly black; last segment minute, white-scaled; penultimate segment with a white ring at the base; long segment with a white ring near the base and another beyond the middle. *Thorax* with blackish integument. Mesonotum clothed mainly with bright yellow scales mixed with some black ones, all narrow; the black scales occur chiefly in four more or less oval patches, a pair on the front half of the scutum and another larger pair immediately in front of the scutellum. Scutellum with rather dense, narrow yellow scales on each lobe. Anterior and posterior pronotal lobes with broad flat scales rather loosely applied, some paler and some darker yellow. Pleurae with patches of flat white scales, including some among the postspiracular bristles, and some in the middle of the mesepimera. Two or three yellow lower mesepimeral bristles. *Abdomen* clothed mainly with black scales, the tergites with small white lateral spots which are not quite basal in position; eighth tergite with some white scales in the middle and along apical margin; sternites with white basal bands, broadest on the first few segments. Hypopygium of moderate size; side-pieces clothed with black scales above and with a row or patch of long broad scales, which are dark brown with yellowish bases, on the inner dorsal margin from near the base to near the tip; no basal lobe. Clasper slender, bare, gradually tapering to a rather fine point, spine inserted at or just before the middle. *Legs* with blackish ground-colour. Femora with rather numerous scattered yellow scales, which on the dorsal surface of the four anterior femora tend to form a row of small spots. Tibiae each with a row of small yellow spots, about five on the front tibiae and about eight on the others, most of these spots connected with a yellow ventral line. Tips of femora and tibiae rather narrowly orange-yellow. First tarsal segment of all legs with numerous yellow scales on the outer or anterior face; first three segments of anterior tarsi and all segments of hind tarsi with narrow white rings at the base. Larger claw of front and middle legs toothed, the other claws simple. *Wings* with the scales on the costa and first vein nearly all broad and flat, some black and some white; scales on remaining veins all narrow, ligulate, and all dark. Upper fork-cell a little longer than its stem, its base slightly nearer the apex of the wing than that of the lower.

♀. Ornamentation as in the ♂. Palpi barely one-fifth as long as the proboscis, black, with indications of two narrow white rings. Cerci short and hidden in the eighth segment; sternites 5–7 prominent apically. Claws of anterior legs each with small tooth, hind claws simple. White scales of costa and first vein less numerous than in the ♂. Wing-length, 2·7–3 mm.

Pupa. Respiratory trumpets short, slightly narrowed at both ends, with rather small oblique opening; immediately behind them a long triple hair. Tufts of first abdominal segment large, subplumose. Lateral tufts of seventh segment with about four branches, of eighth segment large, with about seven branches, nearly as long as the paddles. Paddles broadly oval, slightly truncate apically, without fringe; midrib very strong, at its tip a tuft of about seven branches, one-third as long as the paddle.

Larva. Only the damaged head and siphon of one skin preserved; hair-tufts lost. Head slightly broader than long; scars of hairs *B** almost immediately in front of those of *C*. Antennae spicular, somewhat tapering, fully half as long as the head, terminal bristles over a third as long as the shaft. Siphon strongly chitinised, somewhat tapering, index about 2·5; pecten of about 16 nearly simple and evenly spaced teeth extending to middle; scar of siphonal tuft just beyond pecten; acus very broad. Comb of about 12 strong sharp-pointed teeth in a single row.

Nigeria: Lagos, 1926, larvae in tree-hole (*L. H. Dunn*).

* I propose to use the letters *A*, *B* and *C* for the hairs which Lang designated outer, mid and inner post-antennal hairs respectively; *d* for the pre-antennal and *e* for the vertical hair of Lang.

Type ♂, paratypes 2♀, three pupal skins and one damaged larval skin presented to the British Museum through the Imperial Bureau of Entomology.

This beautifully ornamented species is very distinct in appearance from all other African *Aëdes*, but it evidently belongs to the *furcifer* group of *Aëdimorphus*. It differs from the three other species of the *furcifer* group in having narrow scales on the scutellum and in the spotted tibiae, but resembles them in all essential respects, the hypopygium being extremely similar to that of *A. furcifer*. Oriental species with somewhat similar colouring are *Aëdes* (*Skusea*) *punctipes*, Edw., and *A.* (*S.*) *iyengari*, Edw., but in the latter of these at least, as shown by a specimen from Wara, Sumba I. (*Wirth*), the male clasper has a terminal spine.

IV. The Early Stages of *Aëdes pembaensis*, Theo.

Aëdes pembaensis, Theo., is of interest partly on account of the remarkable structure of the male hypopygium, and partly because it is the type of the subgenus *Skusea*. Its precise location in the complex genus *Aëdes* has been a matter of uncertainty owing to the fact that no very close allies are known. I have associated various other species with it in the subgenus *Skusea* on the ground of external similarity, but the differences of genital structure among these species are so great that this arrangement is clearly not very natural. The early stages of *A. pembaensis* are passed in crab-holes on the shore, as observed by Dr. R. R. Scott and recorded by me in 1924, but hitherto the larvae and pupae have not been described. Specimens have now been received from Mr. A. McKenzie, taken in crab-holes on the sea-shore, containing seepage water from the land, at Dar-es-Salaam in September 1926. These are described below.

Larva (fig. 4, *c*). *Head* pale in colour, slightly broader than long. Antennae rather long, equal to half the length of the head; shaft without spicules, the small 4–6-haired tuft placed before one-third of the length; tip with one moderately long, one shorter and two very short bristles and a long stout papilla. Clypeal spines long and curved, with a fine hair external to each. Hairs on dorsal surface arranged as in *A. amesi* and in the subgenus *Stegomyia*, but not placed quite so far forward; the hair *d* is very minute, with about four branches; *A* is also very small, with about six branches; *B* is simple, *C* double. Mentum almost square-ended, with seven teeth on each side of the middle one, and, in addition, two widely separated teeth at each side. *Thorax* with the large lateral tufts plumose. Spine at base of lower metathoracic tuft very minute, that at base of lowermost mesothoracic tuft rather larger. *Abdomen* with the lateral tufts of the first two segments plumose, with 6–7 and 4 branches respectively; on the following segments the lateral tufts are composed of two simple hairs. Remaining abdominal hairs inconspicuous. Lateral hairs of eighth segment all small; reckoning from above downwards, tufts 1 and 3 have each about four branches, 2, 4 and 5 are simple. *Comb* with about 50 teeth in a patch, the distal teeth considerably larger; individual teeth of peculiar shape, being bifid to the base, the tip of each prong irregularly frayed. *Anal segment* with very small and only slightly chitinised saddle. Brush with 12 tufts, each with about ten branches; none outside the barred area. Gills extremely short, even broader than long. *Siphon* pale in colour, scarcely tapering, index about 3·5. No acus. Pecten composed of 12–16 small fine teeth, some of which show a single basal denticle; the last tooth placed a little beyond middle of siphon. Tuft small, 5-haired, placed half-way between end of siphon and end of pecten, not quite in line with the latter.

Pupa. Respiratory horn about four times as long as its greatest breadth, which is just before the tip; opening very oblique; immediately above and in front of the horn is a long triple hair. Dendritic tuft of first abdominal segment very large; lateral tufts of segments 7 and 8 broken. Paddles shortly oval, not emarginate apically, without fringe; midrib rather strong, with a single strong hair at its tip.

On comparing the above description with those of *A. amesi* (Ludl.) and *A. longirostris* (Leic.) (Bull. Ent. Res. xvii, p. 119) it will be evident that *A. pembaensis* larva has much in common with *A. amesi*, the most important differences being in the position of the antennal tuft and the form of the comb-scales, neither of which characters would seem to be sufficient to warrant placing the two species in different subgenera. *A. longirostris* differs very much more : the shape of the head, arrangement of frontal tufts, spicular antennae and presence of acus on siphon are all features suggesting a closer connection with the subgenus *Aëdes*.

The extremely short gills of *A. pembaensis* suggest that the species normally breeds in salt water.

V. Two African *Aëdes* of the Subgenus *Banksinella*.

Aëdes (Banksinella) albicosta (Edw.) (fig. 3, *b*).

This was described (Bull. Ent. Res., iv, p. 47, 1913) as a variety of *B. luteolateralis* ; subsequently I suggested (Bull. Ent. Res. v, p. 274, 1915) that it was more probably a distinct species. The original specimens, all females, came from the neighbourhood of Mombasa, Kenya Colony, and from the Juba River. No further material has been available hitherto, but a series representing both sexes has now been received (Sept. 1927) from Italian Somaliland (Afgoi, inland from Mogdishu) through Dr. G. Franchini of Bologna. The only associated species in the collection were *Anopheles gambiae*, Giles, *A. funestus*, Giles, and *Culex fatigans*, Wied. It would seem therefore that *A. albicosta* is a characteristic species of the lowlands of Northern Kenya and Somaliland. The male may be described thus :—

Colouration much as in the female, but the pale scales of the wing less numerous, and those on the outer half of the costa not conspicuously whitish. Palpi differing conspicuously from those of *B. lineatopennis* (figured by Carter, Ann. Trop. Med. vii, p. 584, 1913, as *B. luteolateralis*) : long segment somewhat swollen on the outer half, which is provided with numerous long hairs on the outer side ; next segment stout and compressed laterally, densely hairy, the hairs on the outer side long near base and tip, much shorter in the middle ; a very small, sharply pointed terminal segment is present. Hypopygium constructed almost as in *B. lineatopennis*, but the short spines on the inner face of the side-piece near the insertion of the clasper are more numerous, and the terminal spine of the clasper is stouter than usual.

The presence of a minute terminal segment of the palpus has not been detected in any other species of the subgenus, but it is very distinct in each of the three males of *B. albicosta* examined. The structure strongly suggests the subgenus *Mansonioides* of *Taeniorhynchus*, and it may be noted also that there is some resemblance between these two groups in the form of the basal lobe of the side-piece of the hypopygium.

Aëdes (Banksinella) palpalis (Newst.).

This was distinguished and figured by Carter (Ann. Trop. Med. vii, p. 581, 1913), the types having been obtained by Newstead at Boma, Lower Congo. Only the male was known, but a long series of females recently examined from Stanleyville, Belgian Congo (*Dr. Mouchet*), are probably this species; Miss A. M. Evans informs me that they agree sufficiently well with specimens in the collection of the Liverpool School of Tropical Medicine. These females are readily distinguishable by colouration from the other species of the subgenus, the diagnostic points being as follows :—

Proboscis more or less distinctly yellowish beneath in the middle, the yellow colour sometimes extending to the upper surface, forming an indistinct ring. Pale scales of mesonotum not quite as deep a yellow as in *B. lineatopennis*, and in addition to the broad yellow borders there is nearly always a pair of narrow yellow lines

running the whole length. Abdomen unbanded above, the tergites with small lateral spots only; tergites 4–6 usually with distinct blackish apical bands, instead of all pale as in *B. lineatopennis*. Hind femora on the outer side yellowish almost to the tip, except for the dark dorsal line (in *B. lineatopennis* they have the outer half all dark). Hind tibiae on the outer side with a large yellow patch in the middle, tip also rather broadly yellow. Wings without any yellow scales on *Cu*; *R* yellow for a short distance only.

VI. On some Species of *Aëdes* found in Singapore.

Aëdes (Aëdes) cyrtolabis, sp. n. (fig. 1, *b*).

♂. Externally similar to *A. virilis*, Leic., and *A. ceylonicus*, Edw. Hypopygium constructed on a similar plan to that of the two species mentioned, but differing greatly in detail. Dorsal plate (ninth sternite ?) slightly emarginate in middle, without spines. Ventral plate (tergite ?) with a pair of very stout wavy rods. Side-piece with pubescent basal lobe entirely hidden by dorsal plate; tip somewhat

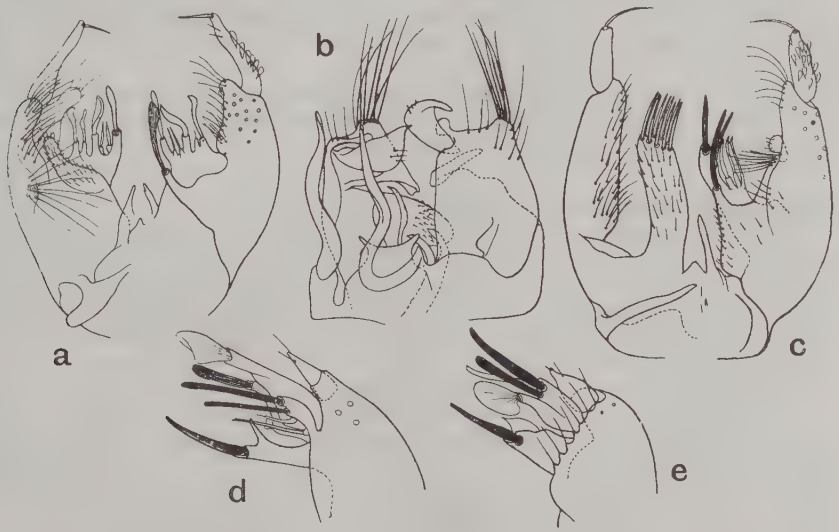

Fig. 1. Hypopygium of ♂ *Aëdes*: (*a*) *A. furvus*, nom. n., left from below, right from above; (*b*) *A. cyrtolabis*, sp. n.; (*c*) *A. fumidus*, sp. n., left from below, right from above; (*d*) tip of side-piece and its appendages (side view) of *A. curtipes*, Edw.; (*e*) the same, *A. simplex*, Theo.

square-ended, a bunch of about eight stout bristles at the outer apical corner; inner apical corner produced into a small club-shaped structure which faces inwards. Clasper undivided, broad and flat in the middle, the tip suddenly narrowed, pointed, and sharply curved almost at right angles to the basal portion.

Singapore (*Surg.-Com. D. H. C. Given*), type and one other ♂ reared from larvae and mounted on slides, details of colour, scaling and chaetotaxy therefore lost.

Aëdes (Aëdes) andamanensis, Edw.

Since this was described (Ind. Journ. Med. Res., x, p. 272, 1922) I have examined specimens from Kotta Tjane, Atchin, Sumatra (*Brug*) and Singapore (*Given*). The hypopygium of both specimens agrees rather closely with that of the type.

Aëdes (Skusea) furvus, nom. n. (fig. 1, *a*).

Stegomyia fusca, Leic., nec *Aëdes fuscus*, O.–S.

Aëdes (Skusea) amesi, Edw., pro parte, nec Ludl.

I have previously used the name *amesi* for Leicester's *Stegomyia fusca* because the latter name is preoccupied, and because there was nothing in the descriptions to indicate any specific difference between the Malayan and the Philippine species. It would now seem, however, that the two species are distinct. Dyar and Shannon have examined the single type female of *amesi*, and report that the mesepimeron has a " patch of white scales, with a diffuse patch of fine hairs intermixed," presumably as in *A. funereus*, Theo., and some other species of the subgenus *Aëdes*. In all specimens of Leicester's species before me there is a small patch of white scales in the middle of the mesepimeron, but there are no hairs mixed with the scales, the hairs being confined to the upper portion of the sclerite. This difference is certainly of specific importance, and as no other synonym is available for use, a new name must be introduced for the Malayan species.

In figuring the male hypopygium of this species (Bull. Ent. Res., vii, p. 223, 1917) I indicated two basal lobes to the side-piece. A re-examination shows that there are three separate lobes, the most ventrally placed lobe bearing the patch of fine hairs shown in my figure.

Leicester states that the palpi are a little shorter than the proboscis, but in the three males before me there is no obvious difference in length. According to Leicester the larvae are found in leaf-bases of atap palms.

Aëdes (Skusea) fumidus, sp. n. (fig. 1, *c*).

In the last paper of this series (Bull. Ent. Res., xvii, p. 119, 1926) I figured under the name *Aëdes amesi* a larva found by Dr. Given at Singapore. Further material of this species has been received in the present collection, and a more careful examination of the males shows that it is distinct from *A. furvus* (*Stegomyia fusca*, Leic.), although evidently closely allied. I am unable to distinguish the females, but the males of the Singapore species differ from *A. furvus* as follows :—

Palpi longer than the proboscis by almost as much as the length of the last segment. Hypopygium : Claspers shorter. Ventral basal lobe larger, reaching more than half the length of the side-piece, without patch of fine hairs but with a row of about five stoutish bristles at its tip. Middle basal lobe with one stout dark spine and three or four short pale bristles, instead of a row of five long processes. Dorsal basal lobe (claspette) with two adjacent terminal rods instead of one. Side-piece with a small hair-tuft arising from a papilla on the inner dorsal side beyond the middle.

The collector's notes indicate that the breeding-places of this species are different from those of *A. furvus*. He writes, " The species was always found breeding in rot-holes or in depressions of fallen trees in the mangrove—always the same variety of tree—a redwood and very hard. It was commonly associated with *A. albopictus*, less commonly with *Culex spathifurca*, and in one breeding-place containing leaves, with *Aëdes niveus*."

Aëdes (Skusea) curtipes, Edw. (fig. 1, *d*).

This species was known only from a few captured females ; Dr. Given has obtained a series of both sexes from larvae. The male has a hypopygium very similar to that of *A.* (*S.*) *simplex* (Theo.) from Ceylon, the resemblance being so close that the Singapore specimens were at first taken to be *simplex* ; there are, however, distinct differences in the subapical appendages, which will be appreciated most readily by

reference to the accompanying figures (fig. 1, *d*, *e*). Regarding the homology of these parts it is difficult to form an opinion ; I believe the clasper to be represented by the small apical piece, but it is also possible that it may be represented by the large process with a leaf-like appendage ; if so the appendage would represent the terminal spine. Apart from hypopygial details, *A. curtipes* is well distinguished from *A. simplex* by the decidedly broader wing scales and darker pleurae.

Another closely related species is *A.* (*S.*) *cancricomes*, Edw. ; all three agree in having two or three long lower mesepimeral bristles. Similar bristles are possessed by *A.* (*S.*) *miachaetessa*, Dyar & Shannon, recently described from females only from the Phillipines ; it is possible this may prove to be identical with *A. curtipes*.

VII. Some Species of the Subgenus *Lophoceratomyia* of *Culex*.

In a later paper in this Bulletin the larvae of ten species of the subgenus *Lophoceratomyia* obtained at Singapore by Surg.-Com. D. H. C. Given will be described and figured. In the present note I have discussed the larvae of three other species which had been found previously, and have compiled a key to all thirteen. Some questions of synonymy are dealt with, one new species is described, and the hypopygial differences between the pitcher-plant species are indicated.

The larvae fall into two main groups, according to their habitat : Those which live in more or less open collections of water, such as *C. fraudatrix* and *C. quadripalpis*, and those which live only in pitcher-plants, such as *C. jenseni*, *C. navalis* and others. An intermediate position as regards habits is occupied by *C. minor*, the larvae of which may be found in rock pools, tree-holes or bamboos. A comparative study of all these larvae brings out the interesting fact that all the pitcher-plant species show more or less pronounced modifications from the ordinary type of *Culex* larva. These modifications occur first in the shape of the head and the form of its appendages. A typical *Culex* larva has a broad head, long spicular antennae with large tuft and long subapical bristles well removed from the tip, and long plumose post-antennal hairs. All these points are well exhibited by *C. fraudatrix*. In all the pitcher-plant species the antennae are shorter, the tuft smaller, and the subapical bristles have moved to the tip. In several of them the head has become very much smaller and more rounded ; the shaft of the antenna has lost its spicules, and the post-antennal hairs are reduced in size. In addition, there appears to be a progressive reduction in the length of the siphon, culminating in the remarkably short siphon of *C. curtipalpis*.

Turning to adult characters, we find that all of the pitcher-plant species belong to the group which has a mammiliform projection on the inner side of the first segment (torus) of the male antenna. Further, all of them are superficially similar, and all with the exception of *C. curtipalpis* lack a distinct leaf on the lobe of the male hypopygium. We may, therefore, conclude that in spite of the striking differences between the larvae, all of these pitcher-plant species belong to the same stock.

In *C. minor*, Leic., the male has a mammilate torus, but the head of its larva has retained all the features of a typical *Culex*. As noted above, *C. minor* is a species which adopts a variety of breeding-places ; it would seem that a portion of this colonising stock settled permanently in the pitcher-plants, and that this important change in larval habits initiated a variability in larval morphology.

The following key will separate the thirteen larvae of this subgenus which are known up to the present :—

1. Subapical bristles of antenna distinctly removed from the tip (slightly so in *cinctellus*) ; head broad ; pecten with 10 or more teeth 2
   All antennal bristles apical 7

2. Middle and inner postantennal hairs each with 4 or more branches; posterior margin of anal plate finely spinose 3
   Middle and inner postantennal hairs each with 2–3 branches; posterior margin of anal plate smooth 4
3. Skin of thorax and abdomen densely covered with fine hairs, obvious under a magnification of 80... ... ... *uniformis*, Theo.
   Skin of thorax and abdomen bare as usual ... ... *cinctellus*, Edw.
4. Antennae with a dark ring at the base; siphon often with a dark ring in the middle; siphonal index 6–8 5
   Antenna dark at base and tip; siphon pale, index 9 *hilli* var. *buxtoni*, Edw.
   Antenna and siphon uniformly pale; siphonal index 9 or more 6
5. Extreme tip of antenna pale; siphonal index about 8 ... *fraudatrix*, Theo.
   Extreme tip of antenna dark; siphonal index about 6 ... *quadripalpis*, Edw.
6. Anal gills over twice as long as the plate ... ... *minor*, Leic.
   Anal gills not much longer than the plate ... ... *mammilifer*, Leic.
7. Head rather broad; pecten with 7–10 teeth 8
   Head more rounded; pecten with 1–4 teeth only 10
8. Inner post-antennal hair with 6–8 branches; siphonal index 7–9 *hewitti*, Edw.
   Mid and inner post-antennal hairs both single, or the inner one double; siphon index about 5... 9
9. Antennae pale; body yellowish ... ... *navalis*, Edw.
   Antennae blackish; thorax blue ... ... *coerulescens*, sp. n.
10. Siphon with 7–8 pairs of long tufts, index about 5; clypeal spines bristle-like ... ... *eminentia*, Leic.
    Siphon with 5–6 pairs of tufts, index about 3; clypeal spines long, stout and straight ... ... *jenseni*, de Meij.
    Siphon with 3–4 pairs of tufts, index about 1·5; clypeal spines very short and thick ... ... *curtipalpis*, Edw.

Culex (Lophoceratomyia) hilli var. **buxtoni,** Edw.

According to the description and figures by Buxton (London School Hyg. Trop. Med., Memoir no. 1, p. 90, 1927) this larva rather closely resembles that of *C. fraudatrix*, but the figure shows the subapical bristles of antenna very near the tip, these and also the apical bristles stronger, and the clypeal spines shorter. Having examined the type slide, which is now in the British Museum, I find that Buxton's figure is slightly inaccurate in these points; in the form of the antenna, as well as in all other structural features, the larva of *C. hilli* is almost exactly like that of *C. fraudatrix*. In the colour of the antennae the species are also similar, the base of the antenna being dark, as well as the part beyond the tuft; the darkening, however, is less conspicuous than in *C. fraudatrix*, and the extreme tip is not distinctly paler. The outer post-antennal tuft has 6–8 branches. Siphon without trace of a dark ring in middle; index about 9.

Culex (Lophoceratomyia) mammilifer, Leic.

This species was reared by Dr. A. T. Stanton at Ginting Simpah, Federated Malay States. One larval skin is in the British Museum collection. This resembles *C. minor* very closely; the siphon is a little longer and more slender still, index about 10·5; anal gills shorter, not much longer than the plate.

Culex (Lophoceratomyia) uniformis, Theo.

Specimens are in the British Museum reared from bamboo stumps at Peradeniya; Ceylon, by Major A. J. MacDougall in 1909. The larvae have a general resemblance to *C. minor* and *C. mammilifer*, but are unique in having the whole of the skin of

the thorax and abdomen densely shagreened with fine hairs, a character which I have not observed in any other mosquito larva. Other points distinguishing *C. uniformis* from *C. minor* are: Clypeal spines stouter. Hairs *B* and *C* each with 4–5 branches. Plate of anal segment with numerous spiny bristles on the upper half of the posterior margin. Siphonal tufts longer, about twice as long as the diameter of the siphon.

Culex (Lophoceratomyia) navalis, Edw. (fig. 2, *d*).

This differs from *C. coerulescens*, sp. n., in the shape of the male clasper, which is slightly swollen beyond the middle, instead of evenly tapering; also in having one of the three rods on the proximal part of the lobe strongly curved and pointed; the latter feature is shown in my figure (Bull. Ent. Res., xvii, p. 118, 1926), but the claspers of the type were broken. The antennal and palpal characters of the two species are quite similar, nor are any other external differences apparent.

Culex (Lophoceratomyia) coerulescens, sp. n. (fig. 2, *e*).

♂. A uniformly dark-coloured species much resembling *C.* (*L.*) *minor*, Leic., and other species of this group. Upright forked scales of head brownish, not distinctly golden. Flat scales of head confined to the sides, those round eye-margins towards middle rather narrow and not conspicuously white. Scales on underside of abdomen pale. Antenna with a blunt prominence on the first segment. Sixth segment with a few hair-like scales not easily distinguished from the ordinary hairs; segments 7–9 with the usual matted tufts, which, however, are smaller than in some species. Palpi of about the same length as the proboscis, slender, almost devoid of hairs, last two segments subequal. Proboscis with slight sub-basal swelling which is not distinctly pubescent. Hypopygium: Side-pieces without long ventro-lateral hairs. Lobe not obviously divided into two portions; its appendages consisting of three long rods, with their tips slightly flattened and twisted; three shorter setae which are pointed, somewhat curved, and not flattened; and, distally, a lanceolate appendage ending in a long point, which perhaps represents the leaf. Clasper tapering, very slender apically, with two fine hairs before the tip and a small terminal spine. Mesosome with a large tubercular portion and a large basal hook, much as in related spines.

♀. Resembles the ♂ in colour and scaling of head. Palpi almost a quarter as long as proboscis.

Borneo: Kuching, Sarawak, "From blue-thorax larva. Nov. 1907. Pitcher plant. Bred" (*J. Hewitt*); type ♂, paratypes 2♂ 2♀ in the British Museum. The specimens had previously been determined by me as *C. hewitti*, Edw., but the shape of the male clasper is different and there are other small differences in the hypopygium. Singapore: a series reared from pitcher-plants, 1926 (*Dr. D. H. C. Given*). These specimens were not distinguished by the collector from *C. navalis*, Edw., which they rather closely resemble.

Culex (Lophoceratomyia) hewitti, Edw. (fig. 2, *f*).

In my key to the Oriental species of *Culex*, this species was stated to have no scale-tufts on segments 6–8 of the male antennae. This was an error; there is a small tuft on segment 8 (as stated in the original description), and a few of the hairs on the seventh segment are peculiarly modified, having a bulbous swelling at some distance before the tip, although they are practically straight, not twisted as in most species. The palpi vary somewhat in length; in some specimens (as in the type) they are slightly shorter than the proboscis, in others of about the same length. *C. hewitti* is externally very similar to *C. navalis* and *C. coerulescens*, the three species

being chiefly distinguished by characters of the hypopygium. All three are very similar to *C. minor*, Leic., which differs in its breeding habits, and in having a well-developed leaf-like appendage to the lobe of the male side-piece.

Hypopygium: Side-piece without long ventral hairs towards base. Lobe not distinctly divided, with two long and nearly straight rods, placed very close together and sometimes appearing as one, and four pointed setae, the distal seta slightly flattened and longer than the others; no leaf. Clasper of peculiar shape, abruptly narrowed near the tip, the tip bent back as a sharp point at right angles to the main axis; terminal spine rather large, sometimes almost continuing direction of main axis (as in dotted line in figure), sometimes almost at right angles to it. Mesosome small, each half divided into two nearly equal and almost smooth fringes.

Culex (Lophoceratomyia) eminentia, Leic. (fig. 2, *c*).

This species seems to be subject to some variation in the male palpi and antennae. In Leicester's type from the Malay Peninsula the palpi are quite five-sixths as long as the proboscis, the last two segments being short but subequal, and the sixth

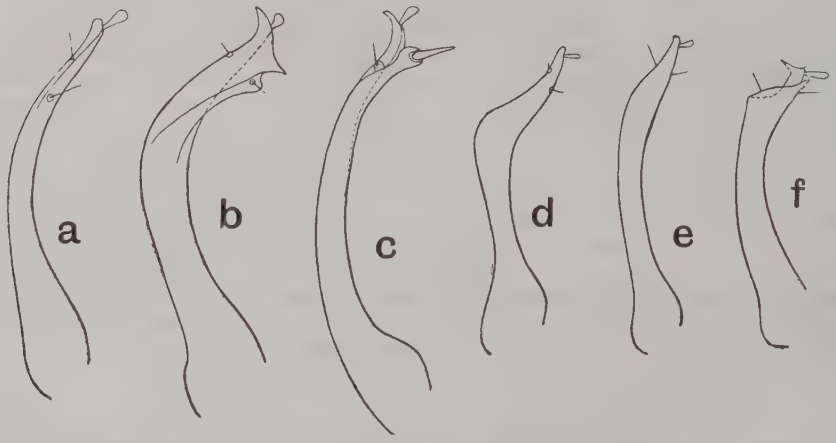

Fig. 2. Male claspers of species of *Culex* (*Lophoceratomyia*) which breed in pitcher-plants: (*a*) *C. jenseni*, de Meij.; (*b*) *C. curtipalpis*, Edw.; (*c*) *C. eminentia*, Leic.; (*d*) *C. navalis*, Edw.; (*e*) *C. coerulescens*, sp. n.; (*f*) *C. hewitti*, Edw.

antennal segment has a conspicuous tuft of eight long, bright yellow scales. In a male in the British Museum from Sarawak the palpi are about three-quarters as long as the proboscis, the last two segments subequal, the scale-tuft of the sixth antennal segment being similar to that of the type. In a number of specimens before me from Singapore the palpi are shorter, being scarcely more than half as long as the proboscis, the last segment very small and sometimes fused with the penultimate; the yellow scales on the sixth antennal segment are less conspicuous and only about four in number. Another specimen from the same place agrees with the Sarawak specimen as regards its palpi, but has the yellow tuft on the sixth antennal segment small; this specimen answers to Theobald's description and figures of *L. brevipalpus*, the type of which was from Singapore. It may be that more than one species is represented in this series, but as all the specimens examined have an almost identical hypopygium I believe the other differences mentioned are more probably due to individual variability.

Hypopygium : Side-piece without ventral hairs towards base. Lobe prominent, but not divided into two parts ; bearing proximally two long rods, blunt-ended and more or less twisted, and two shorter, pointed and slightly curved rods ; beyond these are from four to eight flattened setae, and distally a long process (equal in length to the two long rods) the tip of which is bent and somewhat spoon-shaped ; no leaf. Clasper scarcely tapering, with a double-pointed tip ; the small transparent terminal spine close behind the outer tip, the inner tip with a longish spiny bristle, longer and more conspicuous than the true terminal spine.

Culex (Lophoceratomyia) jenseni (de Meij.) (fig. 2, *a*).

Males of this species from Java have been kindly lent me by Prof. de Meijere. The diagnostic points which they exhibit are as follows : First antennal segment with a nipple-like projection on the inner side as in other species of this group ; sixth segment with the scales hair-like and very difficult to distinguish from the ordinary hairs, not yellow ; segments 7–9 with rather small and inconspicuous tufts of twisted scales. Palpi from three-fifths to two-thirds as long as the proboscis, the last two segments short but subequal in length and about three times as long as broad. Hypopygium : Side-piece without long ventro-lateral hairs. Lobe not distinctly divided ; bearing proximally a very stout, pointed and almost straight rod, and two more slender and slightly longer rods which are placed close together and have their tips bent ; distally three short slender setae and one long, rather stout, flattened, pointed seta which appears to represent the leaf. Clasper very slender, especially towards the tip. Lateral plate of phallosome with a large median basal projection, tip of main portion rounded and finely spinose all over.

As a result of the examination of these specimens it can now be stated that *C. jenseni* (de Meij.) is quite distinct from *C. curtipalpis*, Edw., although the two are very similar superficially and also in their antennal and palpal characters. The hypopygium of *C. jenseni* is very much like that of *C. coerulescens*, sp.n., the most obvious difference being that in the latter species the three proximal rods of the lobe are all of about the same length and thickness and have similarly bent tips. Externally, *C. coerulescens* differs obviously from *C. jenseni* in its smaller size and longer palpi.

Culex (Lophoceratomyia) curtipalpis, Edw. (fig. 2, *b*).

This was described (Bull. Ent. Res., v, p. 127, 1914) from Borneo. Later (Bull. Ent. Res., xii, p. 78, 1921) I placed it as a synonym of *Cyathomyia jenseni*, de Meij. It now appears that these two are quite distinct species, although they both belong to the subgenus *Lophoceratomyia* ; well-marked differences are to be found in the male palpi and hypopygium and also in the larva. The description of the male may be completed as follows :—

Palpi slightly less than or at most as much as half as long as the proboscis ; the penultimate segment short, not more than three times as long as broad ; terminal segment much shorter, only about as long as broad, and sometimes apparently absent. Proboscis with a sub-basal swelling which is densely covered with fine pubescence. Hypopygium : Side-piece without long ventro-basal hairs. Proximal division of lobe with one blunt rod and one very stout sickle-shaped pointed process ; distal division with one long blunt rod, several shorter, curved, pointed setae, and a large leaf. Clasper somewhat enlarged at the tip, which has two slightly reflexed points, terminal spine small.

VIII. The Male of *Culex atriceps*, Edw.

Culex atriceps was described by me (Bull. Ent. Res., vi, p. 105, 1926) from a single female collected by Mr. Harrison W. Smith at Papeari, Tahiti. The ornamentation

of the head is rather distinctive, the conspicuous line of white scales bordering the eyes recalling the African species of the subgenus *Culiciomyia*, and on account of this resemblance the species was referred with some doubt to *Culiciomyia*, pending the discovery of the male.

This discovery has now been made, the same collector having obtained a long series of the species at the same place, both sexes being represented; a dozen of each sex have been presented to the British Museum through Dr. P. A. Buxton. The collection sent by Mr. Smith included in addition to the present species only *Culex fatigans*, Wied., and *Aëdes variegatus*, Dol. All were reared from larvae, but, unfortunately, none of these were preserved.

The male resembles the female in ornamentation, but its structural characters do not support the reference to the subgenus *Culiciomyia*; there are no outstanding scales on the palpi and the hypopygium does not show any marked resemblance to

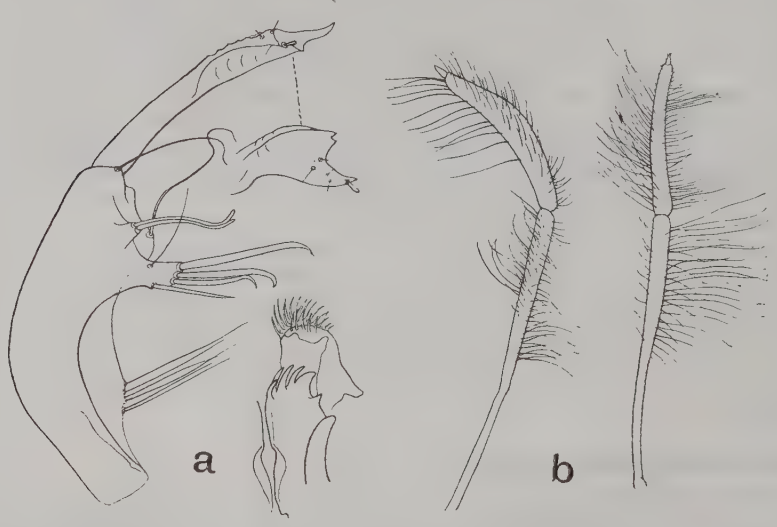

Fig. 3. (*a*) *Culex atriceps*, Edw., hypopygium of ♂, side view of side-piece and clasper (hairs omitted), tip of clasper from another view-point, and half of basal structures; (*b*) *Aëdes* (*Banksinella*) *albicosta*, Edw., palpus of ♂ from side and from above.

the species of that subgenus, nor indeed has it a close affinity with other known Australasian or Oriental species of *Culex*. The majority of the specimens have the claspers directed straight backwards instead of folded in the normal manner, a peculiarity which has not been noted in any other species of the genus.

The occurrence of what appears to be a peculiar endemic species of mosquito in Tahiti is of considerable interest, as it is the only case at present known of a mosquito occurring on a Pacific island which is not obviously related to a mainland form. Future collecting may perhaps reveal the presence of this species or its parent stock in Papua, the New Hebrides or New Caledonia.

The following is a description of the male sexual characters :—

Antennae with well-developed plumes. Palpi of the same length as the proboscis, quite slender and almost devoid of hairs; no outstanding scales on the long segment; last two segments subequal in length and slightly turned upwards. Claws of anterior legs very unequal, each with a longish sub-basal tooth. Hypopygium (fig. 3, *a*)

ochreous, of the usual *Culex* type, but in most specimens the claspers directed straight backwards, not folded in. Side-pieces moderately hairy ; in addition to the usual hairs on the outer surface there is a small group of long hairs directed ventrally. Lower portion of lobe rather prominent, with four rods, the shortest of which is quite straight, the other three somewhat hooked at the tip ; upper portion of lobe with two rods placed close together (rather short and somewhat twisted) and a long curly hair ; no leaf. Clasper long, stout, almost straight and rather irregular in shape, the tip slightly expanded and bifid, one of the points bearing the short terminal spine. Tenth sternites small, tips densely spinose, all the spines pointed ; basal expansion slight, not forming a definite arm. Halves of mesosome broad, flat, with three or four rather large teeth at the tip on the inner side, but otherwise undivided.

IX. A new *Uranotaenia* from Fiji.

The species described below is the first *Uranotaenia* to be recorded from Fiji, and is also of interest on account of the unusual features of the larva. It is now known that larvae of different species of this genus are much more varied in their characters than was at one time supposed, and the new species is very different from any hitherto known. The specimens were sent by the collector to the London School of Hygiene and Tropical Medicine, and the types have been presented to the British Museum by Dr. Buxton.

Uranotaenia colocasiae, sp. n. (fig. 4, *a*, *b*).

A rather large, dark brown species without special ornamentation. *Head* with a narrow and rather ill-defined border of creamy scales round the eyes, remaining scales all dark. Proboscis dark, not remarkably short though not longer than the abdomen ; tip hardly swollen in either sex. Palpi about as long as the clypeus. Antennae of male moderately plumose, last two segments together scarcely longer than the preceding four. Antennae of female not longer than proboscis, pilosity extending the whole length of the segments. *Thorax* with integument of mesonotum and pleurae uniformly dark brown ; scales all narrow, dark brown ; bristles blackish, normal in arrangement, those of mesonotum very long. Two bare lines on scutum between the bristles. *Abdomen* entirely blackish brown above, lighter beneath, especially towards base. *Legs* dark brown, undersides of femora lighter ; last two or three tarsal segments of all legs becoming pale brownish to creamy white. No special modifications in legs of male ; first segment of front tarsi almost as long as the tibia in both sexes, of hind legs very slightly longer than the tibia. *Wings* brownish-tinged ; scales all dark, those on the forks lanceolate to ovate-lanceolate. Upper fork very short, only about half as long as lower. Halteres blackish. Wing-length, 3 mm.

Larva. *Head* shortly oval, slightly longer than broad. Clypeal hairs all simple, except the small posterior one, which is bifid ; they are crowded towards the front. Clypeal spines short and thick. Antennae short, almost cylindrical, with a slightly branched hair placed well before the middle ; apical bristles and papillae not half as long as the antenna. Mentum with a trifid central tooth and four others on each side, all about equally large and somewhat pointed. *Thorax* with the hairs nearly all single and simple ; lateral spines short. *Abdomen* with the longer hairs mostly double on the first few segments, not plumose. *Eighth segment* with lateral tufts all very small ; plate small, not very strongly chitinised, with 6–10 teeth on its posterior margin, these teeth differing from those of other species of the genus in being sharply pointed with a pair of strong basal denticles. *Anal segment* ringed, shorter than broad. Dorsal hairs and those of brush plumose ; brush containing only four pairs of hairs, the first bifid, the others single. One long simple lateral hair arising from plate. *Siphon* conical, nearly twice as broad at the base as at

the tip and only about 1·7 times as long as its breadth at the base. Pecten represented by one or two sharp-pointed teeth close to the base, these teeth not fringed but with few fine denticles at the base. Tuft represented by a single rather stout hair placed distinctly before the middle. Hairs on valves very short and inconspicuous. Anal gills equal, longer than the siphon and quite twice as long as the anal saddle, tips rounded.

Pupa. Lateral hairs of abdominal segments 5–7 stoutish, but simple, those of segment 8 a little stronger and plumose on one side at the base. Paddles very finely fringed, strongly emarginate apically, with a fine simple curly hair outside the midrib.

Fiji: Ovalau Island, iii.1927; larvae obtained in axils of "taro" and a series of adults reared (*R. W. Paine*).

In its complete lack of ornamentation this species resembles *U. papua*, Brug (New Guinea) and *U. kalabahensis*, Brug (Sunda Is.). It is a larger and darker species than the former, but rather closely resembles the latter in nearly all respects; the chief difference appears to be that in *U. kalabahensis* the first abdominal tergite

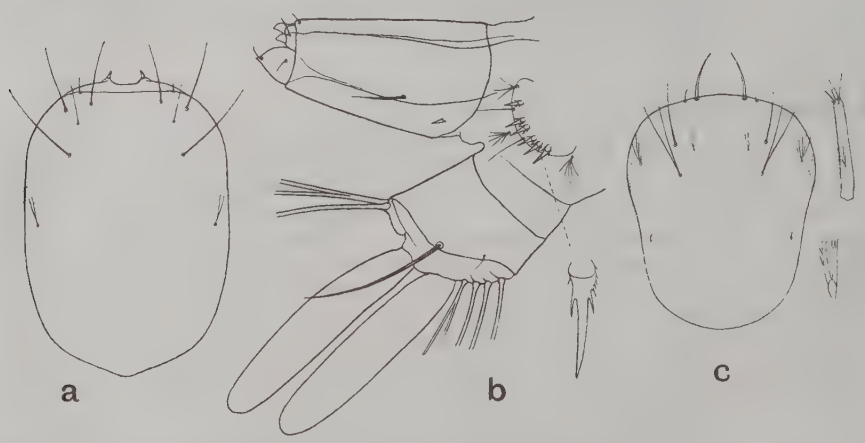

Fig. 4. (*a*) *Uranotaenia colocasiae*, sp. n., clypeus of larva; (*b*) end of abdomen of same; (*c*) *Aëdes* (*skusea*) *pembaensis*, Theo., clypeus, antenna and comb-scale of larva.

and the base of the second have pale scales, whereas in the new species the abdomen is uniformly dark above. The most striking of the many peculiarities of the larva are the reduction of the pecten to one or at most two sharply-pointed teeth, and the rudimentary tufts of the eighth segment. Had not the adults been reared the larva could hardly have been referred to *Uranotaenia*.

Concerning the capture and distribution the collector writes:—

"It was unfortunate that the larvae and adults came from different batches, but I am prepared to vouchsafe that they belong to the same species, as I have bred all my adults of that species from larvae kept in the lab. taken from taro axils, and these are quite impossible to confuse with any other larvae here, and are the only ones which make use of that habitat. The distribution of this mosquito appears extraordinary to me. On this last trip (July 1927), during which I visited a number of the eastern islands of the group, I kept a look-out for this species, and searched cocoanut husks and taro on most islands. So far I have only found it on three

islands (Ovalau, Koro and Gau) in the very centre of the group, and it is not present on Viti Levu or on any of the small islands which form the Lau or eastern group of Fiji."

X. Two new Brazilian *Sabethes*.

The specimens described below were collected by Miss C. Longfield in Matto Grosso, Brazil. The locality is at an altitude of 2,000 ft. on the headwaters of the River Paraguay, between Cuyabá and Diamantino; the insects were taken in dark places in forest. Although similar in most respects to known species from the Amazonian region they show well-marked specific differences; the same appears to be true of the other insects brought back by Miss Longfield.

Sabethes argyronotum, sp. n.

♀. *Head* clothed behind and at the sides with metallic blue-green scales. Proboscis very slightly swollen towards tip, rather short; palpi about one-quarter as long as the proboscis. Clypeus slightly pollinose, but not distinctly silvery when seen from in front. Antennae with the first few flagellar segments short; the first shortly oval, the second also oval, but slightly longer, the following three each a little longer; verticils not more than 2–3 times as long as the segments, none on the underside of the first few segments. *Thorax* clothed above with metallic green scales; pleurae silvery white as usual. Postnotum with its upper surface wholly covered with silvery-white scales; four black bristles. *Abdomen* green above and at the sides, white beneath, the colours slightly incised. *Front legs*: Femora blue, a little white at the base beneath. Tibiae blue, with a small paddle occupying the distal three-fifths of the upper surface and the distal half of the lower surface, but not extending on to the tarsi. Tarsi blue, the second segment white on the inner side, this colour extending indistinctly on to the third segment. *Middle legs*: Femora blue. Tibiae with a large black paddle occupying the distal half and continued for the whole length of the first tarsal segment both above and below; before the paddle is a large white patch on the under side of the tibia. Second tarsal segment white, with a long white fringe above; third white on the inner side, black on the outer side; fourth and fifth all black. *Hind legs*: Femora blue, with a narrow white line beneath. Tibiae blue, without any outstanding fringe. First tarsal segment blue, with a small paddle on the outer half; second and third blue-black, without fringe; fourth and fifth white on one side, black on the other. *Wings* iridescent, scales blackish, broad and truncate. Wing-length, 4·7 mm.

Brazil: Melguierra, Rio Amolar, 2♀, 26–29.v.1927 (*Miss C. Longfield*).

This is closely allied to *S. schausi*, D. & K. (Central America to Amazon region), differing in the extent of white on the tarsi, but more especially in having the paddle of the front legs confined to the outer half of the tibia.

Sabethes longfieldae, sp. n.

♀. *Head* clothed with blue scales above, green at the sides and white below. Proboscis and palpi blue-black; proboscis shorter than the abdomen, slightly swollen at the tip; palpi about a quarter as long as the proboscis. Clypeus bare, appearing silvery when seen from in front. Antennae with the flagellar segments subequal, except the first, which is oval, and the last, which is longer; verticils 4–5 times as long as the segments, giving the antenna a somewhat plumose appearance, the hairs occurring on the lower as well as the upper side of all segments except the first. *Thorax* clothed above with metallic green scales; pleurae silvery white as usual.

Postnotum with four black bristles mixed with which are apparently a few inconspicuous dark scales, otherwise bare. *Abdomen* green above, sides of tergites rather broadly white, the line separating the colours rather irregular. *Front legs*: Femora blue, a little white at the base beneath. Tibiae blue; a fringe of scales on the outer half, especially on the upper surface, forming a small paddle which is only about three times as wide as the tibial diameter. Tarsi purplish, with a little white beneath at the tip of the third segment and the base of the fourth. *Middle legs*: Femora blue. Tibiae all blue, with a black paddle on the outer half, extending the whole length of the first tarsal segment both above and below; the fringe of the upper surface is longer than that of the lower, and the whole paddle is narrower than in the last species. Second tarsal segment blue on about the basal half, white on the apical half, more extensively so above, where the scales are slightly raised; third segment white; fourth and fifth black. *Hind legs* bluish, without trace of paddles; last two segments white on one side. *Wings* with scales and membrane somewhat iridescent; scales broad and truncate. Wing-length, 4 mm.

Brazil: Melguierra, Rio Amolar, 1♀, 24.v.1927 (*Miss C. Longfield*).

Closely allied to *S. kappleri*, Bonne (Surinam), differing in having less white on the front and middle tarsi, and the paddle of the middle legs entirely black.

WHEAT BLOSSOM MIDGES (CECIDOMYIDAE, DIPTERA). DIFFERENCES BETWEEN *CONTARINIA TRITICI* (KIRBY) AND *SITODIPLOSIS MOSELLANA* (GÉHIN).

By H. F. Barnes, B.A.,
Rothamsted Experimental Station.

It is highly regrettable that in the past whenever Cecidomyid or midge larvae have been found in ears of wheat the presumption has been that the species concerned was the wheat midge, and it was therefore recorded as *Contarinia tritici* (Kirby).

How far-reaching this mistake may be, can readily be understood when we read that Dr. Felt, the American authority on gall-midges, came to the conclusion in 1912 that no species of midge attacking wheat ears in America could be referred to *Contarinia tritici* (Kirby), although it had been stated in print countless times that

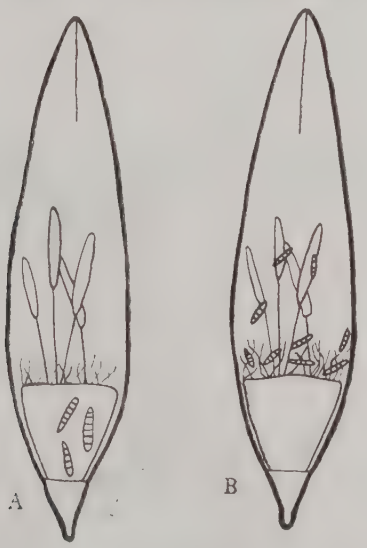

Fig. 1. Position of larvae in flower of wheat (diagrammatic): A, *Sitodiplosis mosellana*; B, *Contarinia tritici*.

this species was responsible for the great losses suffered by the growers of wheat in the American continent. Dr. Felt[1] stated that the midge which did the damage was *Sitodiplosis mosellana* (Géhin).

The same mistake is continually being made in this country. Midge larvae on wheat ears, therefore wheat midge, therefore *Contarinia tritici* (Kirby)—this seems to be the trend of thought of those who record *tritici* as the cause of damage.

The only excuse that can be made for the error is that the observers concerned have not looked up the literature for themselves. B. Wagner[2] in 1866 described, and compared very fully with *Contarinia tritici* (Kirby), a midge which he named *Diplosis aurantiaca*. This midge is now considered synonymous with *mosellana*, Géhin.

It is a matter of the greatest ease to distinguish between *Sitodiplosis mosellana* and *Contarinia tritici*. In the egg stage, the larval stage and the adult midge stage, *Sitodiplosis mosellana* is orange to carrot-red ; in the same stages *Contarinia tritici* is golden yellow in colour.

A further difference, which is to be used in field observations, is the position of the larvae on the wheat kernel : *mosellana* larvae are to be found actually on the face of the kernel itself, while those of *tritici* are to be found in the brush among the anthers and pollen at the top of the kernel (fig. 1).

If the material is sent for identification, the colour may perhaps be faded. This is not essential for identification. Make a quick temporary mount of the larvae in water, and look for the " anchor process " to be found on the ventral surface near the head. In *mosellana* the emargination is much deeper than in *tritici* (fig. 2, A, C.)

Fig. 2. Larvae of wheat blossom midges : A, anchor process of *Sitodiplosis mosellana* ; B, anal extremity of *S. mosellana* ; C, anchor process of *Contarinia tritici* ; D, anal extremity of *C. tritici*.

A further distinguishing character is the form of the anal extremity of the larvae (fig. 2, B, D). In *mosellana* there are four anal papillae slightly chitinised at their extremities ; but in *tritici* the posterior segment bears two very prominent rounded tubercles heavily chitinised, with a pair of smaller, non-chitinised papillae armed with a small seta on the outside of the chitinised tubercles. The last pair of spiracles are also very conspicuous on the posterior margin of the 8th abdominal segment. In *mosellana* the last pair of spiracles are not conspicuous and are not on the posterior margin.

If it is necessary to identify adult midges which have lost their colour, again make a temporary water slide. The ovipositor is the distinguishing character. In *mosellana* the ovipositor bears at its extremity two fairly large lamellae with a much

smaller one ventrally. In *tritici* the extremity of the ovipositor is very sharp and needle-like. In both species the ovipositor is very extensile, but more so in *tritici*, in which the fully extended ovipositor is quite as long as the rest of the midge.

It is most probable that males will never be seen unless they are reared.

There are several other species of midges whose larvae are to be found in wheat ears, but they occur only in small numbers and cannot be called serious wheat pests.

The differences which have been pointed out above will separate *mosellana* from *tritici* and also prevent those species from being confused with any other species which attacks wheat blossom.

Descriptions of both adult female midges are appended (fig. 3).

Contarinia tritici (Kirby).

Female. Length, 2 mm., without ovipositor. Antennae, 2+12; two basal segments golden yellow, flagellar segments grey; first and second flagellar segments fused; each flagellar segment with basal cylindrical enlargement and short neck,

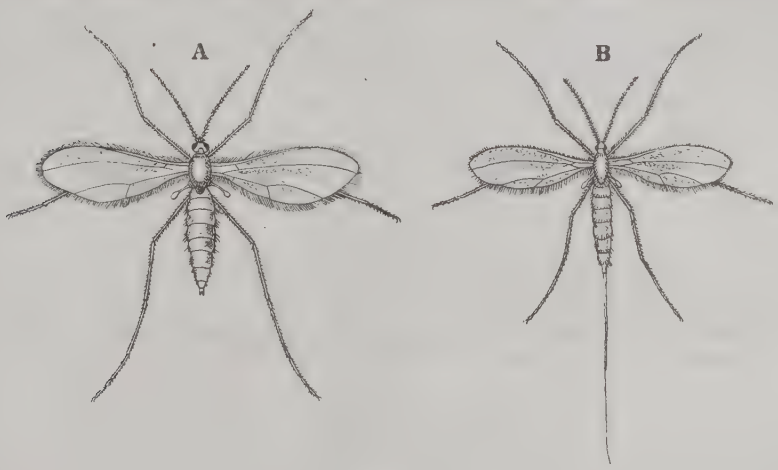

Fig. 3. Adult female midges: A, *Sitodiplosis mosellana* (Géhin); B, *Contarinia tritici* (Kirby). (After Wagner.)

each enlargement with two rings of applied circumfila joined by a longitudinal thread, the distal ring sometimes with very short loops, and a basal and distal ring of stout setae; enlargement of first flagellar segment $1\frac{1}{2}$ to 2 times as long as that of second, enlargement of third flagellar segment about $3\frac{1}{2}$ times as long as neck, which is slightly longer than broad, enlargement of tenth flagellar segment about $2\frac{1}{2}$ times as long as neck, which is about $2\frac{1}{2}$ times as long as broad; terminal segment with rounded cylindrical elongation slightly shorter than neck of penultimate segment and bearing minute setae as on all enlargements but not necks. Palpi with 4 segments bearing long setae; basal segment small, subglobular; second globular, three times as large as first; third cylindrical, slightly longer and narrower than second; terminal segment slender, longer than third. Face golden yellow. Thorax pale brown-yellowish. Wings transparent, iridescent; third vein interrupts costa at tip of wing, fifth vein forked. Abdomen golden yellow. Legs golden yellow with long pale hairs; claws simple, strongly curved, about as long as empodium. Ovipositor very long, retractile, aciculate, as long as abdomen and thorax when fully extended.

Cecid. 482, 483, 484, 485, in the writer's collection.

Sitodiplosis mosellana (Géhin).

Female. Length, 2–2·5 mm. Antennae, 2+12; two basal segments orange to carrot-red, flagellar segments grey; first and second flagellar segments fused; each flagellar segment with basal elongated enlargement with moderately long neck, each enlargement with applied circumfila and proximal and distal ring of long stout setae; enlargement of first flagellar segment not much longer than that of second, enlargment of third flagellar segment about twice as long as neck, which is about three times as long as broad, enlargement of tenth flagellar segment about twice as long as neck, which is about four times as long as broad; terminal segment with rounded cylindrical elongation slightly shorter than neck of penultimate segment and bearing small setae as on all enlargements but not necks. Palpi with 4 segments bearing long setae; proximal segment quadrate; second rectangular, about twice as long as first; third cylindrical, about as long as second; terminal segment nearly one. third as long again as third and slightly swollen distally. Face orange-yellow Thorax pale brown dorsally, otherwise yellowish. Wings dark transparent, bluish iridescent; third vein interrupts costa at tip of wing, fifth vein forked. Abdomen orange to carrot-red. Legs straw-coloured, with slightly darker hairs; claws simple, moderately curved, about as long as empodium. Ovipositor moderately long, about one-half the length of abdomen when fully extended, lamelliform, lateral lamellae about $2\frac{1}{2}$ times as long as broad, basal lamella small.

Cecid. 486, 487, 488, 655, in the writer's collection.

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(1) Felt, E. P. (1912). Observations on the identity of the wheat midge.— Jl. Econ. Ent., v, pp. 286–289.

(2) Wagner, B. (1866). *Diplosis tritici* K. und *Diplosis aurantiaca* n. sp.— Stettin. Ent. Zeit., xxvii, pp. 65–96 and 169–187, pl. iii.

METHODS EMPLOYED IN BREEDING *OPIUS HUMILIS*, SILV., A PARASITE OF THE MEDITERRANEAN FRUIT-FLY (*CERATITIS CAPITATA*, WIED.).

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Plant Pathologist, Department of Agriculture, Paget East, Bermuda.

(Plate XIII.)

The Mediterranean fruit-fly (*Ceratitis capitata*, Wied.) first reached Bermuda about 1865, and since that time has been a pest of the first importance on all kinds of thin-skinned fruits. Peaches, which formerly grew in great abundance in the island, were rendered unproductive, and loquats, sapodillas, Surinam cherries, peppers, and to a lesser extent citrus, papaws, sugar-apples and guavas, were severely infested.

In 1907 a campaign was commenced under government auspices, inspectors being employed to destroy all host fruits and to cut back certain fruit trees. This campaign was carried on vigorously for four years, but although the numbers of the fruit-fly were greatly reduced, no permanent benefit was secured. This was probably owing to the fact that, unknown to the inspectors, the fruit-fly was propagating itself on broad beans and to a lesser extent on bananas, as recently shown by the present writer. The widespread occurrence of thickets of the Surinam cherry (*Eugenia uniflora*, L.) also greatly impeded the work of the inspectors.

Through the kindness of Dr. H. F. Willard, Entomologist at Honolulu, and through the co-operation of the United States Federal Horticultural Board, a consignment of 1,082 parasitised puparia of the Mediterranean fruit-fly was dispatched from the Hawaiian Islands on 29th January 1926, and arrived in Bermuda on 15th February. These puparia had been placed by Dr. Willard in lots of about twenty in vials plugged with cotton-wool, and packed in a tightly soldered tin. It was found that the most rapid route was *via* Vancouver and New York, the consignments being forwarded without delay by the Federal Horticultural Board's representatives in these cities.

On their arrival the vials were placed above sand in stender dishes covered over with muslin or fine lawn. The first consignment yielded 45 males and 21 females of the parasite *Opius humilis*, Silv. It had been previously decided to introduce only this parasite and none of the other three which had been assembled and liberated in Hawaii in 1913, since Pemberton and Willard had satisfied themselves that the *Opius* was the most effective and that the other three parasites acted in unfavourable competition with it. Hence other parasites, such as *Tetrastichus giffardianus*, Silv., which issued from the Hawaiian material, were destroyed.

A simple method of breeding the parasite suitable for Bermuda conditions was soon evolved, and it is with the object of describing this that the present note has been written, in the hope that it may prove useful in other countries where the introduction of this important parasite is attempted.

When the parasites hatch out they are transferred to a cylindrical glass lamp-chimney 9 inches in length and $1\frac{3}{4}$ inches in breadth, the end of which has been covered over with a piece of fine lawn secured by an elastic band. The pronounced negative gectropism of the insects just after hatching makes this operation very simple. Into the cylinder is then inserted a cardboard trough containing suitable infested fruits. The trough is made of a strip of thin white cardboard some 7 inches long and $1\frac{1}{2}$ inches wide folded longitudinally down the centre. An incision about $\frac{1}{2}$ inch long is then made at each end of the strip and these ends held together by means of ordinary wire paper-fasteners (Pl. xiii, fig. 1).

In Bermuda the most suitable fruits for breeding the parasite are Surinam cherries (*Eugenia uniflora*), which fruit throughout the summer and autumn, and loquats (*Eriobotrya japonica*), which fruit throughout the winter and spring. These fruits are practically always severely infested with larvae of the fruit-fly and are of a suitable size for manipulation in the cylinders. Each cardboard trough will hold about ten fruits of Surinam cherry or loquat.

After the tray containing the fruits has been placed in the cylinder the uncovered end is covered over with a piece of lawn in the same way as the other end, and the insects are fed by rubbing on one of the pieces of lawn a honey and water mixture. This is prepared by adding four or five drops of honey to a watchglass about three-quarters full of water. A second piece of lawn is fastened over the moistened piece to prevent too rapid evaporation of the sweetened liquid and to keep off ants, Drosophilid flies, etc. The cylinders are then placed at an angle of about 45° in a suitable-sized box facing the light in a cool position.

Under such conditions mating takes place readily, and since the insects are confined in a narrow space over the fruits, there is abundant oviposition by the females, which run about over the surface of the fruits searching for the fruit-fly larvae. Sweating of the fruits is reduced to a minimum.

It has been found sufficient to feed the insects in the morning and evening. During very hot weather water may be placed on the covering during the heat of the day. It has been found that if some half-dozen females are present the fruit-fly larvae in one of the cylinders will become sufficiently parasitised in the course of one day. Hence the fruits are removed next morning and placed on clean sand in glass jars, the mouths of which have been covered over with cheesecloth. The parasites are transferred to clean tubes and fresh trays of fruit are introduced. The parasites hatch out from the fruit-fly puparia about a fortnight after pupation.

Under the conditions described some three-quarters of the fruit-fly larvae become parasitised, and the parasites emerge three or four days after the majority of the fruit-flies.

In 1926, from the material already mentioned, and a second consignment received on 15th March, which yielded 57 males and 6 females, many hundreds of the parasites were bred and a total of 80 females and 66 males were liberated throughout the islands.

The absence of the writer from the Colony during the late summer prevented further breeding of the parasite in 1926.

Through the continued kindness of Dr. Willard, however, a further consignment of parasitised puparia was dispatched from Honolulu on 20th May 1927, and, travelling by the same route as formerly, arrived in Bermuda on 6th June. From this material 9 females and 100 males of *Opius humilis* were secured, a sufficient number for further breeding, which was carried through successfully throughout the summer. It is hoped that in consequence of the numbers liberated during 1927 this parasite will establish itself in Bermuda.

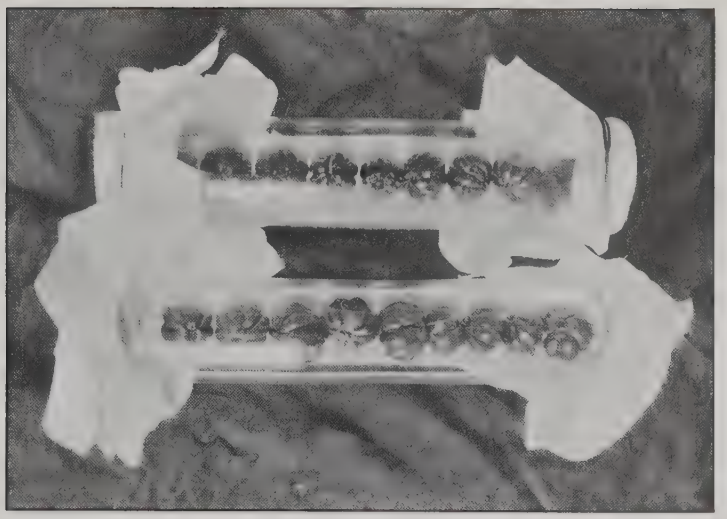

Fig. 1. Glass cylinders containing trays of Surinam Cherries infested with *Ceratitis capitata*, used in breeding *Opius humilis*.

Fig. 2. Materials for breeding *Opius humilis*.

ON THE ECONOMIC STATUS AND BIONOMICS OF *SMINTHURUS VIRIDIS*, LUBB. (COLLEMBOLA).

By W. Maldwyn Davies, B.Sc.,
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(Plate XIV.)

The inclusion of species of the order Collembola among the list of injurious insects has, from time to time, given rise to considerable scepticism among those concerned with economic entomology. It is, therefore, thought desirable to place on record controlled experiments which leave no doubt as to the depredations of one species, *Sminthurus viridis*, Lubb., of this primitive group of insects. Further, our knowledge of the bionomics of Collembola is so scanty that data obtained with reference to the life-history and habits of this particular species may be of interest.

Geographical Distribution and Description.

Sminthurus viridis, Lubb. (fig. 1) is the only British species now included in the genus *Sminthurus*, of the subglobular forms (Symphypleona) of Collembola. This

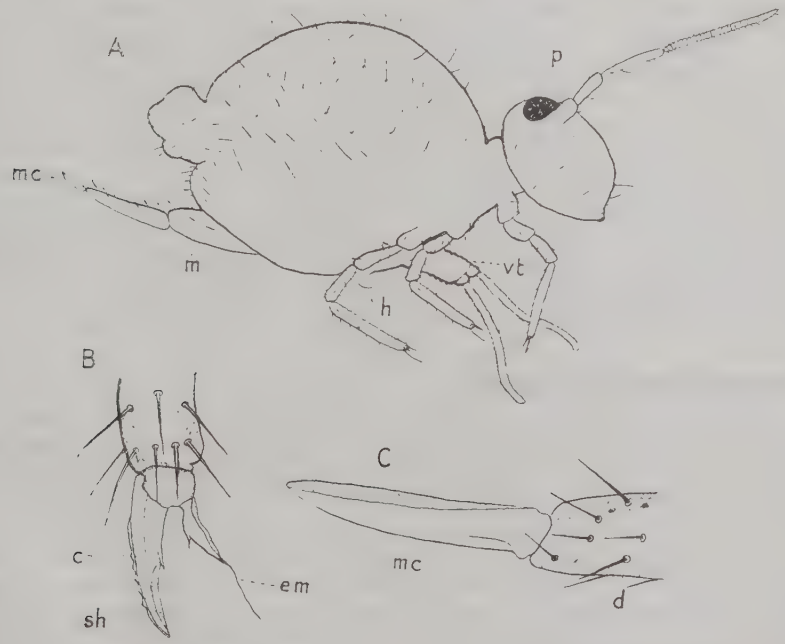

Fig. 1. *Sminthurus viridis*, Lubb.: A, adult, ×40; *p*, pigment surrounding eyes; *vt*, ventral tube with extended warted vesicles; *h*, hamula; *m*, mandibles of furcula; *mc*, mucro; B, foot of left posterior leg, ×270; *c*, tarsal claw; *em*, empodium; *sh*, membranous sheath; C, furcula, ×270; *d*, dentes; *mc*, mucro.

greenish yellow springtail is found commonly, especially in spring and autumn, on grassland and clover leas all over the British Isles, while its distribution abroad is very wide, it being recorded from Australia, New Zealand, and the whole Palaearctic region. The average size of adult specimens is 2·0–2·5 mm.; the head is anteriorly

obtuse, the angle enclosing the mouth-parts, which are adapted for both biting and sucking. The eyes, situated on a patch of black pigment on the posterior half of the head, stand out in contrast to the green body. The 4–jointed antennae, slightly anterior in position to the eyes, are also green except for the terminal segment, which is reddish in colour and is marked off into a series of about 20 constrictions, each with a whorl of fine hairs around its circumference. The thoracic segments are very much reduced, being telescoped between the head and the abdomen, the latter comprising about two-thirds the size of the entire insect. The legs are five-jointed and terminate in two unequal tibio-tarsal claws (fig. 1, B).* The abdomen, subglobular in form, bears ventrally the characteristic appendages of Collembola; the ventral tube is long and its walls are covered with warted prominences; the *hamula* or "catch" on the 3rd segment is well developed, as also is the *furcula* or "spring" with its stout *manubrium* and elongate *dentes* and *mucrones* (fig. 1, C). The whole body and legs are covered with fine hairs, and there are no glandular openings on the furcal segment.

Sminthurus viridis is phytophagous in its feeding habits, despite the fact that many of its related species are saprophytic. Lubbock[1] in 1873 stated that "some species of *Smynthurus* live on leaves"; this was the first indication that Collembola may be of economic importance. *Sminthurus viridis* is omitted in Theobald's[2] list of injurious species of Collembola in 1910, but it is possible that some of the previous records of damage by *Sminthurus* sp. may have referred to this particular species. The first authentic record of damage by this species appears to be that of Lea[3] in 1920, when under the popular name of "lucerne flea" it was reported to cause considerable damage to that particular host-plant in South Australia. Subsequent reports (1921–1924) from the same area have been published, and among its host-plants are lucerne, clover, Cape dandelion, beans, potatoes, sugar-beet, oats, barley, and grasses. *Sminthurus viridis* was declared a pest under the Plant Diseases Act, 1924, in New South Wales.[4] It is interesting to note also that under the new scheme of the Empire Marketing Board (1927) for the distribution of parasites of insect pests to the Colonies, one of the first demands was that from Australia for parasites of this insect. In Great Britain, however, its economic significance appears to have been overlooked, and probably owing to its elusive habits, its depredations have been included among those of species of *Apion*, *Hypera*, etc.

Experimental Evidence of Damage.

During an investigation of the economic position of Collembola the writer was able to make detailed observations regarding the occurrence and habits of *Sminthurus viridis* on clover leas at Rothamsted. On witnessing, under a hand-lens, several specimens feeding on clover leaves and realising the enormous numbers present, it became desirable to estimate, at least qualitatively, the amount of damage caused by these insects. A series of 15 flower-pots containing uniform, insect-free soil, was set up; each was covered by means of a lamp-glass (basal diameter $3\frac{1}{2}$ inches) and, after 50 seeds of wild white clover (*Trifolium repens*, L.) had been sown in each, the top of the lamp-glass was closed by a cap consisting of a circular iron ring (5 in. diameter) covered with fine muslin. These pots were placed in the insectary, where conditions were comparable to those out of doors except that watering was necessary. The clover seeds germinated in 5 days and were allowed a further 5 days to develop before being infested with the Collembola. At this period the 10 most uniform pots of clover were selected for experimental work. The average number of *Sminthurus viridis* for that particular surface area in the field was ascertained by taking 40 counts within the lamp glass on the clover lea on Little Knott field; 6 proved to

* Specimens mounted in Keilin's medium eveal a wavy membranous sheath (*sh*) adjacent to the outer edge of the upper claws.

be the average number of individuals per unit area. On 16th March 1926 a quantity of *Sminthurus viridis* was swept from the field and 6 adult specimens were placed in each of the 5 clover pots in the insectary; the 5 remaining being kept as controls. On the following day the clover in the infested pots showed obvious evidence of damage, and individuals of *Sminthurus viridis* were observed feeding indiscriminately on the upper and lower surfaces of the leaves. Later observations showed that frequently the outer epidermis, upper or lower as the case may have been, was left untouched, giving a skeletonising effect as seen in Plate xiv, fig. 2. There was ample evidence that feeding took place during both day and night, and under very warm dry conditions feeding and movement were confined to the base of the herbage. The effect of attack by these few individuals was soon evident and is clearly seen in the photographs (Pl. xiv, fig. 1) taken on 5th May. One control and 2 infected pots are shown and illustrate the extent of damage caused to clover by 6 individuals of *Sminthurus viridis* for a period of 10 weeks. It should be added that the pots were observed daily and the six individuals counted; in the event of death of an individual another specimen was added. The marked effect was very evident at the end of 15 weeks, when the clover, under the favourable conditions of the control pots, outgrew the height of the lamp-glasses.

This conclusive evidence, together with personal observations in the field, convince one of the damage this species may do, especially on young clover leas. The fact that *Sminthurus viridis* has been observed by the writer to feed also on turnips, mangels, barley, oats, wheat and grasses, makes it possible for this insect to exist on other crops in the rotation and thus tide over arable conditions and be present when the field is laid down to clover or grass.

Realising the fact that *Sminthurus viridis* had several host-plants, experiments were set up with a view to discovering, if possible, whether this species was selective in its feeding habits. Ten large earthenware dishes, 8 inches in diameter, were filled with insect-free soil, and 20 seeds of each of the following grasses or clovers of a common seed mixture were sown in separate rows: Wild white clover (*Trifolium repens*, L.), late-flowering red clover (*Trifolium pratense*, L.), perennial rye grass (*Lolium perenne*, L.), Italian rye grass (*Lolium italicum*, A.Br.), cocksfoot (*Dactylis glomerata*, L.), timothy (*Phleum pratense*, L.). The dishes were then covered with large glass cylinders, 7 inches in diameter, closed in above by muslin caps. When the seedlings had become fully established 20 specimens of *Sminthurus viridis* were introduced into each cage. Feeding took place more or less indiscriminately, except that the wild white clover showed evidence of greater attack in the earlier stages. The insects were allowed to feed for 14 days, after which the grasses and clover plants were examined individually. Counts of damaged plants at this stage gave no significant difference, as specimens of all the species were found to be attacked. These negative results were surprising in view of the fact that ample evidence was obtained in the field by sweeping that there was a greater preponderance of *Sminthurus viridis* on patches of clover over those areas where little clover existed. It may be, however, that the conditions of confinement in these cages prevented any selective habit being established. Specimens of *Sminthurus viridis* have been swept from grassland at Rothamsted in every month of the year, and thus the damage caused by this pest over such a period must be considerable.

Control Measures.

It is regretted that up to the present no opportunity for investigating a practical method of control has occurred, but from general observations it is thought desirable to suggest the following methods. Sweeping of infected areas with tarred sacks, as used against another species *Bourletiella hortensis* on mangels,[5] would no doubt reduce the numbers considerably, but the presence of the "nurse crop" prevents

this from being done at the critical stage in the life of the young seedling clover or grass. The extremely delicate structure of *Sminthurus viridis*, and the presence of destroyed specimens on stones and elsewhere following a heavy rolling, suggest that this operation, together with chain-harrowing would assist in reducing the numbers of springtails. By arranging tarred sacks in front of the roller, the efficiency of this method would be increased. In this connection it may be of advantage to note that Spafford[6] recommends close grazing by sheep and chain-harrowing as a means of reducing the numbers of the lucerne flea in New South Wales. In exceptional cases, such as greenhouse attack, or heavy local infestation, dusting with 5 per cent. nicotine sulphate has afforded a control.[7] No insect parasites have, as yet, been bred from Collembola, so that it remains for predatory enemies to keep these insects in check. The chief of these, so far as the writer is aware, is a small black spider (unidentified as yet). The scarcity of *Sminthurus viridis* on Little Knott field at Rothamsted, when these spiders were present, was very evident; its sudden method of approach is extremely efficient in capturing its prey. The remark by several farmers that black spiders were eating their clover is no doubt associated with this fact.

Bionomics.

Apart from the fact that Collembola undergo no metamorphosis, little is known regarding the life-history of this primitive group of insects. During the present

Fig. 2. A typical batch of eggs of *Sminthurus viridis* laid on damp decayed leaves. × 15.

investigation many interesting observations have been made on the habits of *Sminthurus viridis*; these are included here as a preliminary account, as it is hoped to carry out a more detailed study of this subject later.

As previously stated, specimens of *Sminthurus viridis* have been collected in the field during each month of the year. Specimens caught in the field were periodically brought into the insectary, where they were placed on clover leaves in small glass dishes, lined with filter-paper which was kept continually damp. Under these

conditions eggs were easily secured. Oviposition was observed each month from March 1926 to November 1926, observations having been unavoidably suspended for the remaining months. The eggs (fig. 2) are pale yellow in colour, with smooth delicate chorion, and 0·25 mm. in diameter at the time of oviposition. During oviposition the female stands with legs spread well apart and lowers its head until it touches the filter-paper, its antennae being held in a dorso-posterior position. A yellow substance slowly issues from its anal end, which is raised ; the mass being originally without definite shape gradually assumes a spherical appearance. With the yellow globule protruding the female raises its head and lowers its anal end until the spherical mass touches the filter paper. The mass, or egg as it proves to be, adheres to the surface, and the female after vigorous movement eventually releases itself. During this process the egg, and subsequently a batch of eggs, become covered with excreta issuing from the anus, which in some cases completely hide the eggs. This, no doubt, accounts for the fact that it is extremely difficult to discover eggs in the field. After oviposition the female turns round and touches the egg with its antennae and feet. The eggs are laid in batches varying in numbers from 2 or 3 to 30 or 40, according as to whether the female is disturbed or not during oviposition. Eggs are usually laid on damp decaying leaves and other moist surfaces at the base of herbage ; occasionally they were found singly on the underside of the lower clover leaves.

The dishes in the laboratory were retained at an average temperature of 15° C., and damp conditions were maintained continuously. The average diameter of the egg at oviposition is 0·25 mm. The diameter gradually increases, and when at 0·27 mm., 20–25 days after oviposition, the eyes and antennae are visible through the delicate chorion. Shortly after this stage an equatorial split occurs, which widens as the two halves of the chorion are gradually forced apart. Under the conditions mentioned, hatching took place between 35 and 40 days after oviposition. Emergence is effected by the anterior half of the chorion being pushed off by the head of the individual, and frequently vigorous movement is necessary before the insect frees itself from the egg. The spring, or furcula, is at first fully extended, but immediately the individual is free, it retracts its furcula under its abdomen, after which it is capable of movement by leaping. Its size on emergence is 0·4 mm. Specimens have been observed feeding a day after emergence. Gradual growth takes place until the individual becomes mature in about 8–10 weeks, according to atmospheric conditions. No mating was observed, nor has any ever been recorded among Collembola. It is hoped that further observations may yield information on this matter.

Whereas in all elongate species (Arthropleona) of Collembola cast skins are exceptionally common among the haunts of these species, none were observed in the case of *Sminthurus viridis*. Despite lengthy observations with a view to witnessing this phenomenon, no indication of moulting was seen.

The writer is grateful to Dr. A. D. Imms for the valuable advice and facilities rendered during this investigation.

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Fig. 1. Experimental pots containing 50 plants of wild white clover, showing the damage caused by six specimens of *Sminthurus viridis* in ten weeks; the middle pot is the control.

Fig. 2. Leaves of wild white clover (*Trifolium repens*) showing damage under controlled conditions caused by *Sminthurus viridis*, Lubb.

THE LIFE-HISTORY OF THE BLACK CURRANT GALL MITE, *ERIOPHYES RIBIS* (WESTW.) NAL.

By A. M. Massee,
East Malling Research Station.

(Plates XV & XVI.)

Introduction.

The black currant gall-Mite, *Eriophyes ribis* (Westw.) Nal., may reasonably be described as being one of the most important amongst the numerous pests that infest soft fruits in this country.

This gall-mite was described briefly in the first place by Westwood[1] in 1869, though its presence was known to fruit-growers many years before this date. In fact, it was recognised as being a serious pest of black currants in a number of localities in Scotland as far back as 1850.

From 1869 up to the present time the mite has been spread from one locality to another, aided by insects, etc., and during its travels a vast amount of damage has resulted to black currants in most parts of the British Isles.

As a result of the seriousness of this pest a considerable amount of research work has been undertaken in an endeavour to control the mite in the field. In addition, many publications have appeared in scientific journals relating to it.

Owing to the microscopic size of the mite, it is by no means an easy task to follow out its life-cycle under natural conditions, and this fact accounts very largely for the patient researches that have been undertaken in order that many phases in its cycle might be clearly ascertained. Even at the present time there are several details in its history which need further confirmation before they can be accepted as facts.

I. Summary of Past Literature.

For convenience the life-cycle is arranged under several headings, commencing at the period during which the mites enter the newly developing buds, and continuing throughout the year until they re-enter the new buds the following year.

Records of Entry of Mites into Newly Developing Buds.

The period during which the mites enter the newly forming buds of the black currant varies considerably, according to the opinions and observations of different authorities.

One of the earliest records appears to be that of Taylor,[2] who states that the mites enter the new buds at the end of May, whereas Collinge[3] records the mites as entering the new buds at the end of June. In the same article, Collinge presents a table in which the first date of entry of the mites into the buds is shown for a period of five years. These dates are as follows: 2nd July 1900, 28th June 1901, 8th June 1902, 21st July 1903, and 6th July 1904. Warburton & Embleton[4] also record the mites in the buds early in June; their first record being the 8th of the month.

According to some authorities the mites do not enter the buds until the latter part of July. For instance, Newstead[5] does not refer to their presence until 27th July. Pickering[6] also briefly points out that the mites enter the buds before the end of July, and adds that by the end of September many of the buds show signs of infestation. Finally, Lewis[7] in his excellent treatise on this mite remarks, "It was not until towards the end of July (25th) that I first noticed the presence of the mites in the newly formed buds."

Hence it will be seen that the period of entry of the mites into the new buds extends a little over two months, namely, from the end of May until the latter part of July. In exceptional seasons it extends into August.

Season of Development of Big-Buds.

When the mites have established themselves in the new buds, a short period elapses before the infested buds become conspicuous on the bushes.

Watt[8] states that " Big Buds begin to appear in July–August, become abundant in September, and in mild seasons begin to mature in November and December." Collinge[3] remarks that the newly infested buds begin to swell and become irregular towards the end of August or in the beginning of September ; a table covering a period of six years shows that the buds were first noted to become swollen on the following dates : 20th Sept. 1899, 10th Sept. 1900, 28th Aug. 1901, 20th Sept. 1902, 14th Sept. 1903, and 7th Sept. 1904. Lewis[7] records that many of the buds are swollen by the middle of September, especially those in the vicinity of the dried-up buds that have burst. In conclusion, Newstead[5] writes : " September. I found the mites present in the majority of the new buds, some of which, and more especially the terminal ones, were showing unmistakable evidence of the disease."

It appears that the season of development of big-buds varies considerably from year to year, and that their presence is noted much earlier in some localities than in others. Some observers record big-buds in July, while others do not note their presence in numbers until September and October, or even as late as November.

The Egg Stage.

Lewis[7] writes at length on the egg stage of the mite, and after repeated examinations definitely proves that eggs may be present all the year round. He finds they are more numerous in some seasons than others and are regulated to a large extent by temperature. Frosty weather during January or December greatly reduces the number of eggs present. Newstead[5] also records eggs all the year round. Collinge[3] appears to have been the first to observe eggs in the new buds, and points out that they may be found there by the middle of June. The same author refers to the presence of eggs from September to March, stating that they are scarce in December. Curiously enough, eggs were not observed from the 14th October 1903 to 30th January 1904. In a much earlier work, Whitehead[9] reports the presence of eggs in the buds early in the year, the first date being 10th February. Whitehead does not appear to know when egg-laying ceases, but suggests that it probably stops as soon as the buds have expanded. In 1915 Lees[10] remarked that eggs first begin to appear in numbers in January. More recently,[11] he states that it is only towards the end of the year that eggs are found in any abundance.

The manner in which the eggs are deposited within the buds has received very little attention. Many observers say that they are scattered at random within the infested buds, in many instances being mixed up with the immature and adult mites. In other words, the eggs are laid singly and without arrangement inside the buds. However, there is one exception. Watt[8] is of the opinion that eggs are laid in some kind of order, and says, when referring to the mites in the buds, " And these were apparently laying eggs in rows, a little above the height where the colony were mainly feeding."

The seasons during which the eggs are found seems to vary very considerably. While on the one hand authorities record their presence all the year round, others note them only at certain periods, generally in the spring and autumn months.

Periods of Migration.

The migratory periods of the gall-mite have been studied to a very large extent. This may be accounted for by the fact that at this season the mites commence to live and feed without protection on the outer bud-scales, shoots, and leaves. This is the only season when it is possible to apply an acaricide for their destruction.

Spring Migration.—Detailed records of the first appearance of mites after their emergence from the big-buds in the spring months have been obtained by Collinge[3] over a period of eight years. They are summarised as follows : April 1899, 19th April 1900, 12th April 1901, 30th April 1902, 26th April 1903, 15th April 1904, 20th April 1905, and 30th April 1906. Writing in another Journal, Collinge[13] refers briefly to the weather conditions affecting the migration period of the mites. It is found that when the temperature is favourable, mites are seen crawling about the buds, " these having been forced to quit the partially infested buds which now commence to germinate."

Warburton & Embleton[4] find that migration is at its height round about 30th May and is practically finished by the middle of June. The observations of Newstead[5] agree with those of Collinge ; he notes active mites on the young leaves during April.

Lewis[7] also describes a very early migration period as follows, " The first date on which I noticed the presence of a mite outside a bud in the spring was curiously enough the same in 1899 and 1900, namely, 24th March, but this year it was not until 8th April that I first detected a mite crawling over the outside of the bud scales." In the same article Lewis discusses the migratory period in detail and remarks that the most important season is from the middle of April, or earlier, until the end of May. The actual time depending upon the season and the situation of the bushes.

Lees[17] states that the mites migrate from last season's buds from April to June approximately. Finally, Theobald[15] records that the mites are active outside the buds early in March, but finds that the majority are to be seen in April. Early March seems to be one of the first records of the mites outside the galled buds.

The spring migration extends over a very long period in some years, whereas in others it is quite limited. A glance at the above data shows that the migratory period extends from the early part of March until the middle of June ; reaching its height during the latter part of April and in May. Temperature seems to be one of the main controlling factors.

Autumn Migration.—Very few records are available describing an autumn migration of the mites. Most authorities seem to be convinced that once the mites enter the new buds in the spring, they remain *in situ* until the following year. Watt,[8] however, does not share this view, but refers to two great periods of migration, namely, March–April and September–October. " The latter is from certain of the swollen, flattened and ruptured buds, formed from the spring migration." Finally, Watt says, " it is somewhat remarkable that no previous writer would appear to have recorded definitely his belief in an autumn migration, still less in the continuous invasion of the buds."

In 1902 Warburton & Embleton[4] had in mind the possibility of an autumn migration, but they do not appear to have discovered one. They found that the mites increased so rapidly in July and August that a second migration would certainly occur. No such migration was observed, however.

Habits of the Mites following Migration from Big-Buds.

The difficulty of following the movements of the mites with any accuracy, once they have emerged from the big-buds in the spring, possibly accounts for the incomplete records that are available. Much of the information concerning this

period of the life-cycle is due to the researches of Taylor.[2] A number of important facts have been published by various workers at different times, but Taylor's work stands out prominently, and therefore will be referred to in some detail.

Taylor points out that the mites emerge from the deformed leaves of a big-bud and distribute themselves on the outer surface. Some of the mites then leave the bud, find their way down the stems, make a sudden leap into the air, and eventually alight on the leaves in the vicinity o the bud. Mites were found on shoots that had been kept under observation, and with the aid of a strong lens mites were actually seen to be blown on to them. Later it was found that the mites made their way to the petioles. Taylor states, "The movements of the mites could be traced until they arrived at the base of the petiole, when they disappeared between its upper surface and the main stem where the bud eventually shows itself . . . When such a leaf base is dissected, it is found that a small colony of mites has established itself in this position." After some time the mites feed on the tender inner surfaces of the leaf bases, reproduce, and eventually enter the almost invisible buds. A little later in the year, when the lower leaves of the new young shoots begin to harden, the mites leave them and migrate towards the newly developing leaves at the apex of the shoots. These leaves are soft and succulent, and the mites readily obtain food from them. Taylor found many cast skins around the lower leaf bases after careful dissection of a half-grown shoot. An examination of several shoots indicated that mites are more prevalent towards the apex. It is suggested that the habit of the mites migrating towards the apex of the shoots accounts for the fact that the terminal buds of an attacked bush are frequently "big-budded."

Pickering[6] finds that many of the mites leave the buds before June and lay their eggs on the newly formed shoots between the petiole and the buds. On the other hand, Newstead[5] records mites and nymphs on the shoots, but does not record the presence of eggs. In conclusion, Collinge[13] notes mites in large numbers scattered over the stems, in the latter part of May and in the earlier part of June; eggs are not recorded on the shoots.

Dissemination of Mites by Insects, Wind, etc.

The dissemination of the mites from one black currant bush to another, and also from one plantation to others, has been studied only to a small extent. It is known only too well that a healthy plantation may suddenly become infested by gall-mites, but the methods they adopt in reaching the bushes are very little understood, though of special interest.

Warburton & Embleton[4] have been able to trace the movements of the mites after they emerge from the big-buds, and they mention that four species of spiders, the larvae of the currant moth, the larvae of the two-spotted ladybird, the currant aphis, the black ant and various other insects, are responsible for carrying the mites from one bush to another. Lewis[7] finds that frequently the mites are carried by the prevailing winds, the clothes of men working amongst the diseased bushes, and by birds (such as tits), as well as by various insects. The mites also are carried about attached to the bodies of bees, and according to Theobald[15] these insects are one of the most usual means of distribution. Theobald also says that the mites may be spread by the propagation of diseased cuttings from infested bushes.

Leaping Habit of the Mites.

A curious fact in relation to the locomotive powers of the gall-mite was recorded by Warburton & Embleton[4] in 1902. They found that the mites can attach themselves to a branch or twig by means of their sucker-like appendage, which is situated at the anal end of abdomen, and jump off on to passing insects. When describing this incident Warburton states, "After several vain attempts to attach itself to a

passing insect, a mite would cease to wave its legs, remain rigid for a moment, then launch itself forth, torpedo-like into space . . . No great distance was covered by the leap, the longest measures being 4 millimetres, or about 16 times the animal's length."

Effect of Temperature on the Mites.

As already mentioned, Lewis[7] found fewer eggs in January and December than at any other time during the year, and notes that a spell of frosty weather makes a difference to the number present. Lewis also observes that the activities of the mites are greatly lessened during a spell of cold weather, but as soon as the temperature rises the mites become more active.

Taylor[2] states that the sensitiveness of the mites to variations of temperature will control their activities during the migration period. Thus, in a late cold spring there will be a late migration of the mites from the buds, and the reverse in an early season.

That the mites can withstand a great deal of cold weather has been shown by Whitehead,[9] and in a series of experiments he found that the mites could resist a temperature of 20°–29° (Fahr.), still remaining active after being taken from the buds half frozen.

Pickering[6] also remarks that the mites can withstand low temperatures, and apart from a certain amount of sluggishness during cold weather, they become active as soon as the temperature rises.

Gall-Mites living in the Soil.

The possibility of the gall-mite passing part of its life-cycle in the soil has not been overlooked.

Taylor, in 1906, records the presence of mites in the soil on several occasions, " but there did not appear to be any reason to suspect their living there. The mites were in such apparent difficulties that such surroundings were considered unnatural to them."

Theobald[18] mentions that many mites fall to the ground, and sugges s that this accounts for the new shoots coming up badly infested. He then remarks, " Whilst ordinary lime has been found to have no effect, it appears that hot lime put on fairly thickly destroys or checks them, whilst in the soil."

Watt[8] supports the belief of hibernation within the soil, and points out that the experiments discussed by Newstead do not disprove this. He concludes, " The Crichton experiment, on the other hand, appears to support belief in hibernation within the soil." In this experiment a plot of black currants were cut down and removed, and the prunings burned. Soon afterwards the shoots that came up from the stools were infested with mites to a greater extent than before pruning. Two years later the same bushes were cut down to ground-level and burned on the spot. The shoots that appeared afterwards were vigorous and free from mites.

Incidentally, Lees[11] points out that up to 1913 eggs had not been found in the soil, but suggests that the difficulty of finding such small objects might account for this.

Parasites and Predacious Enemies.

The records of the predacious and parasitic enemies of the gall-mite are somewhat vague.

Doubtless the chief parasite is a small Chalcid (*Tetrastichus eriophyes*, Taylor) described by Taylor.[12] The female Chalcid lays her eggs in the big-buds, and the larvae feed upon the mites. The larval stage extends over nine months. Curiously enough, other workers do not refer to this parasite.

Theobald[19] records that the larvae of *Tortrix podana*, Scop., are predacious on the gall-mites. This moth is found in a locality in Northumberland. Newstead[5] mentions that the larvae of lacewing flies (*Chrysopa* spp.) and also of a Syrphid fly are sometimes seen in the semi-open gall buds. These insects, however, were not actually seen feeding upon the mites. Lewis[7] refers to a considerable number of mites and insects found in the big-buds, and Collinge[3] states that a ladybird beetle (*Coccinella 7-punctata*, L.) is predacious upon the mites. Finally, Warburton & Embleton[4] refer to the presence of a small Dipterous larva within the buds, which is apparently that of a Cecidomyiid Fly. A small red mite of the genus *Actineda* is also constantly found in the buds.

Host-Plants.

Although the black currant gall-mite is found most commonly on black currant (*Ribes nigrum*, L.), this plant is by no means its only host. Several other species of *Ribes* are attacked to a lesser degree. Theobald[19] refers to attacks on red and white currants, more especially white. Ormerod[16] records the mountain currant (*Ribes alpinum*, L.) as a host-plant, as also does Nalepa.[24] Taylor[2] notes the mite on gooseberry and describes the nature of the infestation at length.

Massee[14] carried out some experiments at Wisley in order to ascertain whether the black currant gall-mite lived on hazel and writes, " The opinion is held by gardeners and others that the mites from the hazel infect the black currant and produce ' big-buds ' and *vice versa*. . . . These experiments have now been going on for three seasons, and as yet no infection in either direction has been obtained; in other words, the originally healthy hazels have not been infected by the diseased ' Baldwins,' neither have the healthy ' Baldwins ' been infected by the diseased hazels."

Varieties of Currants resistant to Mites.

From time to time several varieties of black currants have been introduced into commerce as being resistant to mites.

Theobald[15] finds that most varieties are attacked by the mite, some, however, suffering more severely than others. Baldwins appear to suffer most, then Black Naples, and Black Dutch and Lees Prolific. The variety Carter's Champion was at first considered to be immune, but now gets very badly diseased. Boskoop Giant is said to be somewhat resistant, probably owing to its very strong growth.

Lees[17] points out that several years ago Boskoop Giant was introduced as an immune variety and remained free for some time; eventually it proved to be most susceptible. Later on, the variety called " French " was introduced, which was also claimed to be resistant. The history of this currant is similar to that of Boskoop, but at the present time it is still somewhat more resistant. The next variety to follow was Seabrook's Black. According to Lees, " This variety has undoubtedly stood the test of time far more satisfactorily." At present three varieties, namely, Resister, Defender, and Mite Free, are claimed to be resistant to mites. Whether this is so or not time alone will prove. Hatton & Amos[25] in 1926 point out that many of the French group are stated to be resistant; " Under our conditions it might be more accurate to say that they do no show big-bud readily." In another Report Lees[11] states that " in general the green-budded varieties are more susceptible than the red."

Lewis,[7] when discussing the question of immune varieties of black currants, states that some of the old varieties grown in Kent are never attacked. Finally, although some observers and growers found certain varieties to be immune or resistant, Collinge[13] did not appear to obtain the same results. Mites were taken from Baldwins and were transferred to most of the known varieties, which in due course became infested.

Other Species of Gall-mites on Black Currant.

No less than four authorities have recorded species of gall-mites on black currant that appeared to them to be distinct from the familiar species (*Eriophyes ribis*, Westw.).

The first record is that of Newstead,[5] who found a single specimen walking amongst the flowers. This mite had the extremities of the body reddish brown with a paler centre, showing a marked contrast in colour from those found inhabiting the interior of the buds. This was the only specimen observed and was considered to be *E. ribis*.

A year later Lewis[7] found half a dozen mites, entirely red in colour, which were situated on scales of a reddish tint, and he concluded that their colour was due to their food. Later on Lewis found some more red mites, and they were almost always near the outside of the buds; in one instance two red mites were found near the centre of the buds.

In 1914 Taylor[2] remarked that it had been suggested that the mites might find shelter under loose bark; "Mites of the genus *Phyllocoptes* were found there, but not *Eriophyes ribis*."

As recently as 1924, Watt[8] found a reddish mite that was assumed to be a modified form of the ordinary white mite, and it was considered to be a distinct species. This species was considerably longer than the common species. Its rings were fewer in number and thicker in structure, and the anal disc was less highly developed. Watt also found what he considered to be a third species, which was much shorter, relatively broader, and of a darker colour, almost black on its extremities. Detailed descriptions of these new forms are lacking.

II. Observations on Black Currant Gall Mite at East Malling.

During the past six years investigations have been in progress at East Malling in relation to the control of *Eriophyes ribis*. These experiments, which were conducted in the field, have terminated, and a full report of the results has been published elsewhere.[20] When these trials had been in progress for a short while, it became obvious that before intelligible results could be obtained, the life-cycle of the mite would have to be studied under local conditions, since several details in its life-history were not fully understood, and this was therefore undertaken.

For convenience the various stages of the life-cycle are arranged under headings similar to those adopted for the first part of this paper.

Records of Entry of Mites into Newly Developing Buds.

The immature and adult mites proceed to enter the newly forming buds towards the end of May, the first date noted having been 25th May. As a rule only two or three mites enter one bud. They pierce their way to the centre of the bud and immediately commence to breed, eggs being found within three or four days of the entry of the mites (Pl. xv, fig. 2). It has been noted that the mites copulate on the leaves before entering the buds.

A large number of newly forming buds were examined during the first week in June 1922, and approximately twenty mites were found in the centre of each, and it was estimated that the buds were infested in the first instance seven days before the examination. Thus the mites would appear to breed very rapidly at this season.

The mites enter the buds considerably later in some seasons than others, as, for example, in 1924, when the first record was obtained on 18th July. However, this date is considered exceptionally late.

Season of Development of Big-Buds.

In an average season swollen buds may be seen on the bushes by the third week in August (Pl. xvi, fig. 2). In exceptional seasons, *e.g.* 1924, enlarged buds were noticed as soon as the first week in August. At present it is not possible to explain why the big-buds appeared much earlier in 1924 ; it is indeed curious, since mites were not found in the new buds until the 18th July, which, as already mentioned, is considered abnormally late in the year.

It does not follow necessarily that the majority of the mite-infested buds are swollen by the third week in August. Many bushes have been observed on which the number of big-buds continues to increase until March. Again, in some varieties of black currants of the Goliath group, some of the mite-infested buds do not develop into big-buds in the normal manner, but dry out the following spring without becoming swollen.[21]

It is not always possible to determine which buds are inhabited by mites before the latter part of July, and even then in some instances their presence cannot be determined with certainty unless the buds are dissected and examined individually with the aid of a microscope.

Egg-Stage.

The eggs of the mite are present all the year round. Immediately after the migration period eggs are deposited on the shoots, and during the flowering season they are frequently laid in the blossoms. They are laid on the leaves and shoots during the summer months.

Unfortunately it has not been possible to ascertain the exact number of eggs laid by one individual, but it is estimated that it is upwards of 100. The eggs are deposited on the leaves and shoots quite irregularly (Pl. xv, fig. 1).

The duration of the egg stage varies very considerably, depending upon the season. The eggs hatch within three to seven days during the spring and summer months ; during the winter the egg stage is extended over a period of three to four weeks. The ova are very large in comparison with the size of the adult mite. Just before an egg hatches it tends to become drawn out, and the form of the mite is visible through the transparent chorion. It is evident that the mites do not devour the egg-shells on emergence, since empty shells are found commonly within the big-buds, frequently in thousands.

Up to the present eggs have not been found in the soil. At the height of the migration period of 1925, a large number of female mites were transferred to a box containing moist soil. They were examined periodically during the four days following the transference, but were not observed to lay eggs in the soil. On the fifth day, the few that could be traced in the box were removed to a black currant leaf, and eggs were deposited on the upper surface within a few hours.

Periods of Migration.

Spring Migration.—The spring migration period depends upon the weather conditions prevailing at the time. The earliest record at East Malling is 1st April 1923. In 1925 migration was delayed until the middle of May ; as a general rule it reaches its height during the latter part of April or in May.

The period of migration does not vary on widely separated groups of plants, or on early and late varieties of black currants. For instance, mites escape from the big-buds of an early variety such as Baldwin at the same period as they do from somewhat later varieties of the Goliath group. Notes were obtained from a number of mite-infested bushes that were grubbed in March 1922. The mites were found to be leaving the drying-up galls and were congregating in little groups at the tips of the shoots. It was not possible to ascertain whether they survived the cold weather conditions which followed.

Autumn Migration.—A detailed study of the mites has been made from June to October, over a period of six years, in order to discover whether there was a second migration period. However, no such migration was observed under local conditions, and it is definitely known that during this period the mites were living and reproducing within the buds.

Habits of the Mites following Migration from Big-Buds.

Directly the mites commence vacating the semi-drying big-buds in the spring, they collect into large groups or colonies, which remain for some time, frequently a a few days, sheltering beneath the outer bud-scales. During this period the mites are very active, but they do not expose themselves to daylight until the conditions (presumably mainly temperature) are favourable, when they move off very rapidly to the outer surface of the big-buds, dispersing in all directions ; in some instances their numbers are such that they cover the entire surface of the buds (Pl. xvi, fig. 1). At this juncture they are just visible to the naked eye, and in appearance the bud looks as if it were dusted with a very fine white powder.

The mites feed on the tender leaves, more frequently on the lower surface, immediately they migrate from the big-buds. The feeding period is followed by oviposition on the leaves and flowers. The mites then make their way to the new growths (by crawling along the shoots) and remain there until the new buds are sufficiently large for them to enter.

Dissemination of the Mites by Insects, Wind, etc.

The methods that the mites adopt to spread from one bush to another have been studied in some detail.

A large number of insects and mites have been caught and examined, and many of them are recorded as being carriers of the gall-mite. These insects were mainly taken from bushes definitely known to be infested by mites ; in some cases they were caught whilst on the wing in the vicinity of a black currant plantation.

During the migration periods of 1925 and 1926 the two Coccinellid beetles, *Adalia bipunctata*, L., and *Coccinella 7-punctata*, L., were found frequently with numerous mites attached to the lower surface and legs. It is suggested by some authorities that these two beetles readily devour gall-mites while they are searching for currant Aphids on the bushes. However, observations do not support this view. Coccinellids could not be induced to feed upon the mites, although they were bred in captivity and were sparingly fed.

In some years the currant Aphid (*Amphorophora cosmopolitana*, Mason) is one of the chief distributing agents of the mites. Frequently little colonies of thirty to forty mites are conveyed at one time attached to the body of an Aphid.

Occasionally the hive bee (*Apis mellifera*, L.) also carries the mites from one bush to another. The mites have been observed clinging to the hind legs of the bee. It may be assumed reasonably that the mites carried by bees are disseminated over a wider area than those carried by Aphids or Coccinellids. Bees mainly act as carriers in sheltered plantations, and in seasons when the conditions are favourable to them.

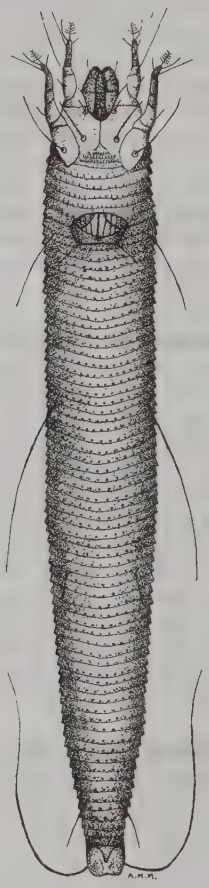

Fig. 1. *Eriophyes ribis* (Westw.) Nal., ♀, greatly enlarged.

Although it is reasonable to suggest that the prevailing winds during the migration might account for the spread of the mites to some extent, the writer has not been able to obtain any evidence to support the theory. On the other hand, an attack seems to spread from a known source of infection to other bushes in the vicinity irrespective of their position or the direction of the wind.

Leaping Habit of the Mites.

As already mentioned the peculiar leaping habits of the mites were first recorded by Warburton & Embleton.[4]

The best period for observing these strange movements appears to be that directly following their migration from the big-buds. The jumping movements are aided largely by the sucker-like appendage situated at the anal end of the body, which is somewhat tapered, the extremity bearing a small movable disc. This disc is divided into two parts, which resemble two flaps when examined from a vertical position, the flaps being drawn together to form a sucker-like foot. A pair of very long stout hairs are attached to the sucker foot ; they are known as the caudal bristles, and are considered to be sensory hairs (fig. 1).

When the mites leave the interior of the drying big-buds they attach themselves to the outer bud-scales with the aid of their sucker foot. They remain in this position for some two or three minutes, moving their bodies with a semi-circular motion, and waving their legs with great rapidity in the air. This process is repeated a number of times. Sometimes the mites jump off the buds while engaged in this peculiar action, but as a general rule they walk slowly over the bud surface, remain stationary, arch their bodies (in a similar manner to the looper caterpillar), and leap into the air, finally alighting on a portion of the plant below that which they occupied previously.

It seems reasonable to suggest that while this process is being carried out, the mites are waiting for some passing insect, in order that they might leap on it and be transferred to other bushes or plantations. This has not been observed in the field or in the laboratory. Nevertheless, some observations tend to support this view. It has been shown elsewhere[22] that as soon as a fine hair is brought into close contact with a mite, the latter attaches itself to the hair and remains there for some considerable time.

Effect of Temperature on the Mites.

The mites very readily respond to change of temperature, especially under artificial conditions.

Three hundred " big-budded " cuttings, growing in moist soil and kept in a cool greenhouse, were examined each day during March 1926. Towards the end of the month, after a spell of sunshine, the mites emerged from the big-buds and migrated to the tips of the shoots. The normal migration period that year proved to be exactly one month later.

Cold weather and frosts do not appear to affect the mites to any marked extent. For example, a quantity of " big-budded " cuttings were obtained from a plantation which had been thinned out in December 1925. The cuttings were actually removed from the plantation at the end of February 1926, and many of them were accidentally trodden into the soil. These cuttings were examined in the laboratory with the aid of a binocular microscope, and active mites were found in a majority of the buds, whatever their condition.

Gall-mites living in the Soil.

Two preliminary experiments extending over two seasons were undertaken to ascertain whether the mites passed any period of their life-cycle in the soil.

It is known that the only possible period the mites could pass in the soil extends from the migration season until they enter the new-buds. Therefore the trials were carried out during the time the mites were living freely on the bushes, the object being to determine whether it is possible for the mites to complete their life-cycle without entering the soil.

The first experiment commenced in 1924. During February 72 cuttings, each 15 inches long, were obtained from badly " big-budded " bushes and placed in twelve glass jars, each containing a little sand and filled with tap-water. The cuttings

were examined weekly until the end of June (when they began to dry out without producing any new growth), and mites were present in large numbers and were very active during the whole of the period. Some of the mites were transferred to a batch of normal cuttings, which had been fumigated, and after a few days they established themselves in the buds. The experiment was discontinued at this stage.

The second investigation was conducted on rather different lines.

A number of " big-budded " cuttings were obtained from a reverted Baldwin. The lower buds were removed, and the bottom halves of the stems were dipped in tree banding-grease. The cuttings were contained in 8-inch pots, filled with moist sand. A disc of cardboard, which had small holes cut in it to allow the stems of the cuttings to pass through, was fixed in a horizontal position, resting on the rim of the pot. The spaces between the card and the cuttings were plugged with cottonwool, in order to prevent mites passing from the soil to the cuttings. This barrier also was covered with grease.

The cuttings were examined at intervals of two weeks until the end of August. Early in September the new growths of the cuttings were removed, and the buds examined in detail. Of these new buds 80 per cent. were found to contain mites.

It seems evident from the above investigations, that the black currant gall-mite is able to complete its life-cycle without entering the soil. This fact is borne out by further observations in the field. A number of soil samples were examined during the migration period, but mites were not discovered in any of them.

Parasites and Predacious Enemies.

A small Chalcid parasite (*Tetrastichus eriophyes*, Taylor) proved to be very common in a black currant plantation badly infested by mites. On 25th November 1924, 500 typical big-buds were collected from the plantation and examined in the laboratory, and 25 per cent. of the buds were found to contain the larvae of this Chalcid parasite.

The larval stage of a lacewing fly (*Chrysopa vulgaris*, Schn.) and the larvae of an undetermined Syrphid fly were found feeding upon the mites during the migration season.

The mites are parasitized also by a minute fungus (*Botrytis eriophyes*, Massee),[12] which is almost always present in situations where the mite is commonly found. However, this fungus is not considered to be of any real importance, since it is not usually common in the big-buds until the latter part of May and in June, and at this season the majority of the mites have migrated from the big-buds.

Host-Plants.

The black currant is undoubtedly the chief host-plant of this gall-mite. Other host-plants included in the genus *Ribes* are the red currant (mainly Fay's Prolific), the white currant and the gooseberry. The American flowering currant must be included as a host, since the mite has been found on this plant in a private garden at Sevenoaks, Kent.

The hazel is not infested by this species of mite. A large number of hazel bushes growing wild in hedges surrounding black currant plantations and showing heavy infestations of mite attack (big-bud) have been examined, and without exception the species of mite producing these big-buds proved to be the nut mite (*Eriophyes avellanae*, Nal.). This species may at once be recognised from the black currant gall-mite by the presence of two pairs of thoracic bristles, situated on the cephalothoracic shield, which are not present on the shield of *E. ribis*.

Varieties of Currants resistant to Mites.

A study of the resistance of certain black currant varieties to mites has been carried out, and the results will be published elsewhere.

These experiments and observations show that most varieties are susceptible to attack, but the degree of infestation differs considerably among the different groups. Some varieties included in the French group may be misleading. The buds in many cases contain mites, but these buds do not become swollen, and thus it is very difficult to determine their presence, unless a detailed examination of the buds is resorted to. Such bushes are referred to frequently as being resistant to attack.

Other Species of Mites on the Black Currant.

Three species of gall-mites have been recorded and described from the black currant. Detailed notes and descriptions of these mites will be found elsewhere.[23]

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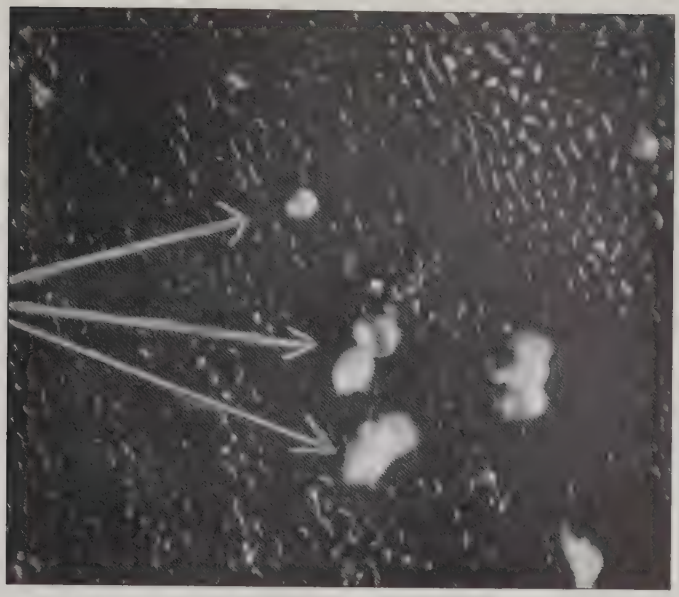

Fig. 1. Eggs of *Eriophyes ribis* on black currant leaf.
(Greatly enlarged.)

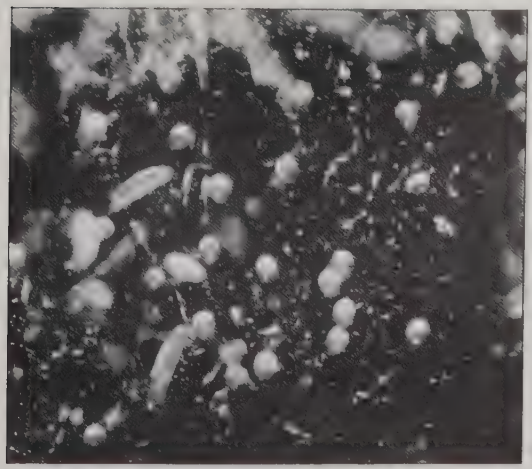

Fig. 2. Portion of new bud showing mites and eggs.
(Greatly enlarged.)

Fig. 1. Gall-mites migrating from big bud. (Greatly enlarged.)

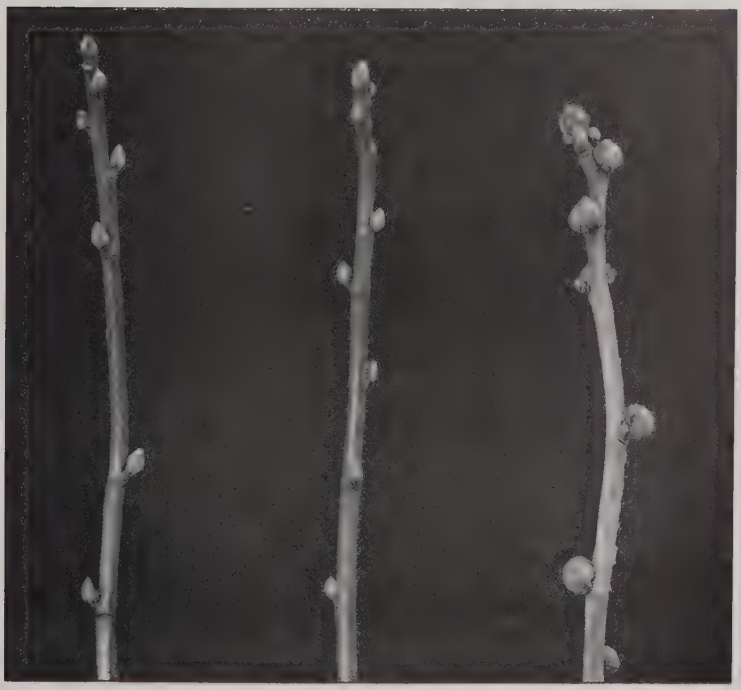

Fig. 2. Black currant shoots showing normal buds (left) and big buds (right)

A NOTE ON AUSTRALIAN TYPHLOCYBINE LEAFHOPPERS, WITH A DESCRIPTION OF A NEW SPECIES.

By Dr. J. G. Myers,
Imperial Bureau of Entomology.

The small and obscure leafhoppers of the subfamily Typhlocybinae are assuming increasing economic importance, firstly by direct damage to the plants on which they live, and secondly as carriers of " virus " diseases.

Their taxonomy is in great confusion, since it is impossible satisfactorily to separate these insects specifically without the minutest study of the external male genitalia, including especially the aedeagus and the genital styles. These organs must be properly prepared, and drawn before mounting, in order that exactly the same orientation may be obtained with each species, or their diagnostic value will be obscured.

It is often a matter of the greatest difficulty to ascertain the original home of a species which suddenly attracts notice as a pest. In most cases the existing knowledge of the older species is not critical enough to solve the problem. What is needed is a thorough revision of the European species, especially genotypes, on a properly comparative basis. In the meantime it is better to describe a new pest in this subfamily as a new species, with adequate figures of structural details, than to synonymise it doubtfully with some inadequately described Old World form.

Scarcely the fringe of the Australian Typhlocybine fauna has been touched. Only the following species have been described as yet :—

1. *Dicraneura honiala,* Kirk., Haw. S. P. Exp. Sta., Entom. Bull. 1, p. 360, 1906. Queensland.
2. *D. aneala,* Kirk., *l.c.*, p. 360. New South Wales.
3. *Kahaono hanuala,* Kirk., *l.c.*, p. 361. Queensland.
4. *Empoasca histrionicula,* Kirk., *l.c.*, p. 361. Queensland.
5. *Eupteryx haematoptilus,* Kirk., *l.c.*, p. 362. Queensland.
6. *Typhlocyba australensis,* Kirk. (*Empoa*), *l.c.*, p. ~~000.~~ Queensland.
7. *T. froggatti,* Baker, Philip. Jl. Sci., xxvii, p. 537, 1925. (n.n.)
   Empoasca australis, Frogg., Agr. Gaz. N.S.W., xxix, p. 568, 1918.
   Typhlocyba australis (n.praeocc.), Myers, Proc. Linn. Soc. N.S.W., xlvi, p. 473, 1921 ; Trans. N.Z. Inst., liv, p. 423, 1923. This species has been introduced into New Zealand, where it is one of the most serious of apple pests, as in New South Wales.
8. *Erythroneura* (?) *melanogaster,* Kirk., *l.c.*, p. 364, New South Wales.
9. *E.*(?) *lubra,* Kirk., *l.c.*, p. 364. New South Wales. The generic position of these two species is doubtful, judging from Kirkaldy's remarks on the venation.
10. *E. honiloa,* Kirk., *l.c.*, p. 365. Queensland.
11. *E. ipoloa,* Kirk., *l.c.*, p. 365. Queensland.
12. *E. honiala,* Kirk., *l.c.*, p. 365; Myers, Proc. Linn. Soc. N.S.W., xlvi, p. 474, fig. 3, 1921. Queensland.
13. *E. sidnica,* Kirk. Haw. S.P. Exp. Sta., Entom. Bull. 3, p. 69, 1907 ; Myers, Proc. Linn. Soc. N.S.W., xlvi, p. 474, fig. 4, 1921. New South Wales.
14. *Dialecticopteryx australica,* Kirk., *l.c.*, p. 72. Queensland.
    [*Aneono,* Kirk., is apparently not a Typhlocybine genus.]

To these 14 species I now add a fifteenth, submitted by Mr. G. F. Hill, Entomologist to the Commonwealth Council for Scientific and Industrial Research.

Erythroneura ix, sp. n.

♂. Colour general deep yellow, occasionally more or less smudged with dark greyish. Eyes dark greyish. Abdomen (except genital segments) dorsally blackish. Lower surface also clouded with greyish. Legs pale yellow.

Length of the vertex from $\frac{5}{6}$ to $\frac{3}{4}$ its width at base, measured across the curve. Vertex broadly rounded in front of eyes. Pronotum broadly rounded anteriorly and very slightly and widely emarginate posteriorly. Base of scutellum as wide as or slightly wider than base of vertex; apex acute.

Aedeagus and genital styles (fig. 1, *a–c*) of same type as those of *E. kiekie*, Myers, *E. cyathea*, Myers, and *E. zealandica*, Myers, from New Zealand, but differing in specific details from any of these, as the figures show (Trans. N.Z. Inst., liv, pp. 424–427, figs. 37–44).

Length, including folded tegmina, 3 mm.

♀. As male, save in following details: Colour a more greenish yellow, the abdomen often darker than in the other sex, especially ventrally, with posterior margins of the segments clear yellow. Edge of abdomen pale.

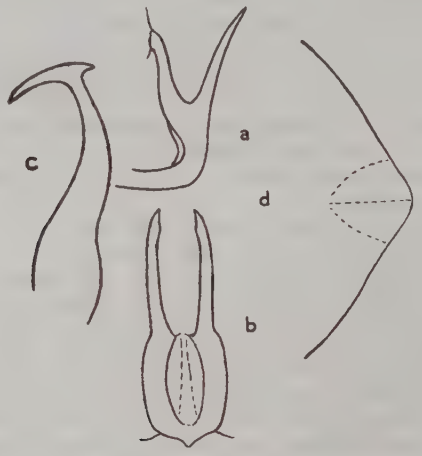

Fig. 1. *Erythroneura ix*, sp. n.: *a*, lateral view of aedeagus, ♂; *b*, posterior view of aedeagus, ♂; *c*, outer view of left genital style, ♂; *d*, subgenital plate, ♀.

Vertex with about same relations of length and basal width, but front margin more conical than in male. Ovipositor fuscous at tip; otherwise genitalia pale. Subgenital plate as in fig. 1, *d*.

Described from 10 males and 5 females, Melbourne, Victoria, 6.xii.1926 (*G. F. Hill*). Stated to be becoming abundant as a garden pest near Melbourne. It attacks almost all kinds of garden plants, vegetables and weeds.

This species is very distinct from *E. honiloa*, Kirk., and *sidnica*, Kirk., the only described Australian species of which, thanks to Mr. Muir, we know the male genitalia. It disagrees with Kirkaldy's short description of the other forms.

Holotype and *allotype* in British Museum. Paratypes, male and female, British Museum and Mr. Hill.

SCIAPHOBUS SQUALIDUS, GYLL. (COL., CURCUL.), A PEST OF ORCHARDS IN UKRAINE.

By N. S. Dekhtiarev,
Central Station for the Protection of Plants in Ukraine.

(Plate XVII.)

Various species of Curculionidae are injurious to orchards in Ukraine, but *Sciaphobus squalidus*, Gyll. (fig. 1) is considered by fruit-growers to be the most harmful, as it attacks the buds of all fruit trees. Mr. Znamenskiĭ* was the first to make an adequate study of the life-history of this insect. The following notes give an account of my own observations and deal principally with methods of control.

Distribution.

Sciaphobus squalidus occurs as a pest throughout Ukraine, and every spring the Central Station for the Protection of Plants receives complaints regarding it. It has also been recorded as causing injury in the northern Caucasus, Crimea, Bessarabia and Hungary. In northern Ukraine the beetles have done great harm in the Kursk district.

Life-history.

The beetle appears in the early spring, about the beginning of April, even before the trees come into bud. At this time of year the cherry trees and the early kinds of pears have hardly begun to become green at the tips of the buds, and no sign of growth can be seen on the apple trees. The beetles begin to feed on the buds of the fruit trees immediately, and later, when the young leaves appear, they attack the flower buds and blossoms.

Oviposition begins in the early days of May. The eggs are shining white, about 0·8 mm. in length and 0·45 in breadth, and are laid under the upturned end of the leaves on many kinds of fruit and forest trees, on bushes, and more rarely on certain herbaceous plants (*Urtica*, *Trifolium*). The female bends the tip of the leaf over the eggs and fastens it down by means of a sticky secretion, which hardens very quickly on exposure to the air. On an average about 20 eggs are laid at a time. Egg-laying ceases about the beginning of June, when the weevils are already becoming rare, usually disappearing after the middle of June. The eggs hatch from the 12th to 15th day, and the larvae drop and bury themselves in the earth rather quickly, descending to a depth of 15–20 inches; they generally feed on the roots of the plants on which the eggs were laid. The damage done to the roots by the larvae is of little importance and does not cause any noticeable injury to the plants. By autumn of the same year the larvae have grown but slightly, and they pass the winter in this state. It is only near the end of the following summer that they attain their full growth, and they pupate early in August in earthen cocoons at a depth of about 20 inches. The beetles emerge in the middle of September, but remain in the cocoon for the winter, issuing only in the early spring of the following year.

Nature of Damage.

Sciaphobus squalidus has been recorded as feeding on a great number of different plants, including practically all fruit trees and bush fruits, rose bushes, and nearly all wild and ornamental broad-leaved trees. Among herbaceous plants this weevil especially prefers nettles (*Urtica*), wormwood (*Artemisia*), *Poa* spp. and other

* Bull. 20, Poltava Agric. Exp. Station, 1914.

Gramineae. Early in spring the beetles eat out the buds of fruit trees; the large blossoms that are at the ends of the branches on pear trees especially suffer from them, and often four, five or more beetles may be seen attacking each of them. When the young leaves and flower buds appear the beetles eagerly eat them. The gooseberry, which opens its leaves very early, attracts enormous numbers of these weevils, as do currant bushes.

From one medium-sized tree nearly 3,000 beetles have been shaken; on an average about 200 or 300 on a tree is considered quite usual in Ukraine. The lowest branches are especially badly damaged, evidently because they are the first met by the insects in their ascent from the ground.

According to numerous communications from fruit-growers, young grafts in nurseries are entirely destroyed by this pest in a short time, if no protective measures are taken.

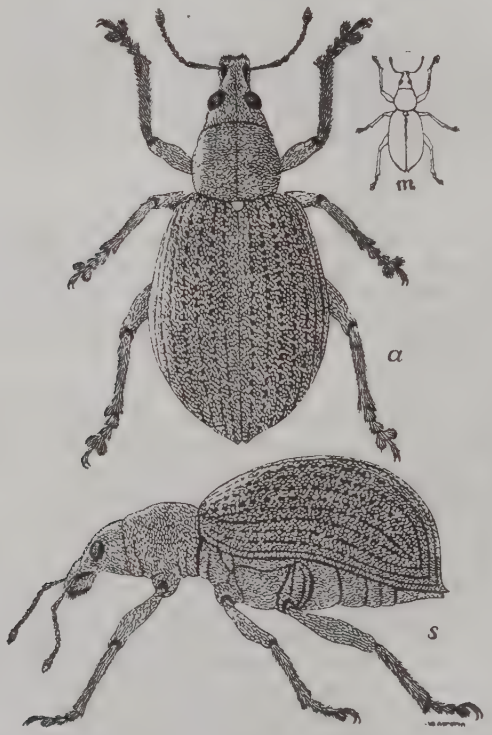

Fig. 1. *Sciaphobus squalidus*, Gyll.: *a*, ♀ from above; *b*, ♀, side view; *m*, outline of ♂. Natural size of ♂, 4·8–7·2 mm.; ♀, 5·5–8·0 mm.

Natural Enemies.

The only parasites and predators of *Sciaphobus squalidus* that are known at present are those that attack the eggs. Among the Hymenoptera, Znamenskiĭ (*l.c.*) was the first to find *Anaphes* sp. (MYMARIDAE) as an internal parasite of the egg; he also observed two species of *Eulophus*, the larvae of which suck the eggs from the outside. Besides these, larvae of *Aeolothrips fasciata*, Hal., and *Haplothrips aculeata*, F., also suck the eggs of this beetle. The *Anaphes* is the most important enemy, because it often destroys 50 per cent. or more of the eggs.

Various Control Measures.

Satisfactory control measures can be taken only against the adult insects, as the larvae and pupae are subterranean. Many other species of CURCULIONIDAE are also injurious to fruit trees, and their combined attacks are sometimes as serious as those of *Sciaphobus* alone. The insects referred to include various species of *Rhynchites* (*pauxillus*, Germ., *bacchus*, L., *auratus*, Scop., *giganteus*, Kryn., *cupreus*, L., *aequatus*, L.), *Byctiscus betulae*, L., *Anthonomus pomorum*, L., *Phyllobius*, *Polydrosus* (especially *inustus*, Germ.), and others. Unlike the *Sciaphobus* these are all insects that have a fairly close association with fruit trees, often having a very clear preference for one or other kind ; as, for instance, *Rhynchites auratus*, which lives chiefly on cherry trees, and *R. giganteus* on pear trees. Moreover, these weevils are all capable of flight, whereas *Sciaphobus* is wingless. On the other hand, for economic reasons the most suitable measure against *Sciaphobus* will be one that can at the same time be utilised against all the other Curculionids.

Many contrivances have been suggested for preventing the beetles from climbing up the tree-trunks. A circular gutter of cement or zinc (made in two semi-circles) filled with water and petroleum may be placed round the base of the tree. Again, wide strips of canvas are sometimes fastened to the trunks, or metal bands of which the upper edge is turned down, etc. But such contrivances are but rarely used, doubtless owing to their high cost. There is, however, one measure of this kind which is often used by fruit-growers ; it consists in placing rags soaked in petroleum or tar on the ground in a ring round the base of the tree. I have examined trees protected in this way several times without finding a single *Sciaphobus squalidus* on them, although numerous other, winged weevils could be shaken off them.

Shaking the Beetles from the Trees.

Shaking the beetles from the trees is the method usually adopted for destroying weevils. It is mostly applied against those species that are specially attached to fruit trees, and as *Sciaphobus* is equally abundant on wild plants, this measure is not nearly so satisfactory against it. In order to be effective, tree-shaking must be carried out by all fruit-growers in a given locality simultaneously, otherwise re-infestation soon takes place. In our experiments, tree-shaking done every other day for two weeks, at the end of April, yielded on an average the same quantity of weevils every time. More frequent shaking, such as daily or even twice daily, could not be carried out on a sufficiently large scale, and such an experiment could not be considered conclusive if applied only to a small area. We cannot but admit that tree-shaking is a somewhat troublesome method, especially in large and old orchards.

Sticky Bands.

The use of a good adhesive band entirely protects a tree from *Sciaphobus squalidus*. The widely used American " tree tanglefoot " and a preparation made by the Strawson Chemical Co., Limited, London, are the best.

In the forests of Ukraine a black adhesive made by Ermisch is widely used against the caterpillars of *Dendrolimus pini*, L. It can also be successfully applied against *Sciaphobus squalidus*, as experiments have shown, and is a cheap substance for wholesale use in forests. It is placed on the tree-trunk, if the bark is old enough, by means of a special wooden spade. The thickness of the smear must not be less than 3 or 4 mm. ; a thinner layer is liable to become dry.

Sticky Sprays.

Sticky bands are useless against winged weevils, nor can they be used against the wingless *Sciaphobus squalidus* on bushes. An attempt was therefore made to find

a means of covering the plants all over with a sticky spray, but without real success. But if a suitable preparation can be devised, we believe that sticky sprays might be very effective in cases in which insecticides do not give the necessary results. For instance, when searching for a good sticker for dormant trees, spraying was effected with well boiled molasses; it acted splendidly, but only for a short time, though all the beetles on the trees at the time were disabled.

Spraying.

The complete covering of leafless trees with a lime spray is much practised by fruit-growers in Ukraine, but it gives little protection to the trees against winged weevils and does not act on *Sciaphobus squalidus* at all, in spite of numerous recommendations to use it for this purpose. Consequently, a lime spray with the addition of insecticides was tried. In order to make the mixture spread properly the hydrated lime was mixed not simply in water but in a well boiled and not very thick flour paste, to which insecticides had previously been added.

The trees were sprayed, and on the next day several small twigs were taken from each of them, and twenty *Sciaphobus* weevils were placed on each batch of twigs. The results are shown in the following table :—

Material.	Number of Weevils dead.				Control, per cent.	Remarks.
	Second day.	Third day.	Fourth-seventh day.	Total.		
Arsenate of lead (dry) 2 lb., water 100 gallons.	0	0	0	0	0	All the buds were eaten.
Arsenate of lead (dry) 10 lb., water 100 gallons.	0	1	0	1	5	All the buds were eaten.
Arsenate of lead (dry) 10 lb., hydrated lime 50 lb., paste 100 galls.	1	2	1	4	20	Buds much damaged.
Sodium arsenite 1 lb., arsenate of lead (dry) 10 lb., hydrated lime 50 lb., paste 100 galls.	3	1	1	5	25	Buds much damaged.

The trees that were sprayed with these materials during inspection bore the same numerous marks of injury as those that were not sprayed, indicating that this method is practically useless for the purpose of protecting the buds from the attacks of *Sciaphobus squalidus*. The beetles feed chiefly on the buds and therefore consume but little poison, or at all events not enough to kill them. It has already been mentioned that most of the bushes, and especially gooseberries, bloom in the very early spring, so that the *Sciaphobus* do not eat the buds, but only the young leaves. A small plot of gooseberries bearing their first young leaves was therefore sprayed at a time when the fruit trees were still quite bare. The following mixture was used : 3 lb. of arsenate of lead (powder), 100 gallons of water, and 3 quarts of ordinary milk, to which 10 oz. of hydrated lime had been added earlier. The application of this spray gave excellent results. Many dead beetles were found on the ground on the third day, and the plants themselves had a very satisfactory appearance in comparison with those that had not been sprayed, the latter having been entirely defoliated by the beetles.

An arsenate of lead spray without milk and lime was not so efficient. The beetles were noticed to have eaten only the outer leaves of the sprayed bushes and perished much more slowly. It was observed also that the insectide covered the leaves very unevenly.

Dusting.

Hand dusters are very rarely used in Ukraine. While dusting can be successfully applied to bush fruit and medium-sized fruit trees, against *Sciaphobus squalidus* on leafless trees it gave no results, as only an insignificant quantity of the insecticide adhered to the trees. For the protection of unopened buds it is therefore useless, but when the buds have opened, dust can be applied with the same success as a spray. The effect of the different dust mixtures on *Sciaphobus squalidus* was also tested on gooseberries in leaf.

Experiment 1. Some gooseberry bushes that were severely attacked by the beetles were well covered with lime dust. The beetles were noticeably affected, although the bushes ultimately proved to be considerably damaged. Dead beetles were not found.

Experiment 2. The gooseberries were treated with a mixture of 15 parts calcium arsenate and 85 parts lime. The dust covered the young leaves very well. In this case beetles were found dead beneath the bushes on the next day (Pl. xvii, fig. 1). The poison dust also thoroughly covered the weeds growing near by. The dusting was repeated after rain on the fifth day. The beetles appeared in insignificant numbers on this area; not more than five or six to each bush. The plants had quite a satisfactory appearance and evidently benefited from this treatment.

Experiment 3. The dust was made of a mixture of 15 parts arsenate of lead and 85 parts sulphur. More than half the beetles perished on the third day, the remainder being obviously affected. The dust was again applied on the third day, and after a lapse of another two days only isolated beetles could be found. The plants showed only very insignificant signs of injury.

Fig. 1. A good type of hand machine for dusting trees.

Fig. 2. Dead *Sciaphobus* under a dusted Gooseberry bush.
(Natural size.)

NOTES ON THE BIONOMICS OF COTTON STAINERS (*DYSDERCUS*) IN NIGERIA.

By F. D. Golding, M.A., F.E.S.,
Government Entomologist, Nigeria.

In the introduction to a previous paper[2] the writer intimated that he had discovered that there are two distinct forms of the species *Dysdercus superstitiosus*, F., and that a rhythm exists in the proportions of the sexes. The scope of the present paper is to give a detailed description of the information obtained on these two points; to collate data on the bionomics of the species of *Dysdercus*, accumulated in the years 1922–1927; and to amplify an account of the alternative food-plants given in a paper by Pomeroy and the writer.[7]

The majority of the observations recorded were made on, or in the vicinity of, Moor Plantation, Ibadan, the headquarters of the Agricultural Department. The three species of cotton grown on Moor Plantation in the period under review were *Gossypium hirsutum* var. (Allen's Long Staple), *G. peruvianum*, and *G. vitifolium*, which are designated Allen, Meko and Ishan, respectively, in the present paper; Allen is an introduced American species, while Meko and Ishan are indigenous.

The Species of Dysdercus observed.

The following species of *Dysdercus* have been found on cotton at Ibadan*: *superstitiosus*, F., *melanoderes*, Karsch, *fasciatus*, Sign., *intermedius*, Dist., and *haemorrhoidalis*, Sign. In addition two specimens of *migratorius*, Dist., have been caught at light at Ibadan, and Mr. O. B. Lean has taken one or two specimens of *nigrofasciatus*, Stål, on cotton at Ilorin, about 85 miles N.N.E. of Ibadan.

1. *Dysdercus superstitiosus*, F.

Prior to September 1923, the writer had no opportunity of making detailed examinations of the stainers migrating to cotton early in the season; but had observed in the latter part of two previous seasons that the vast majority of adults of *superstitiosus* were red in colour, there being considerable variation in the shape of the markings on the hemelytra, some individuals bearing distinct fasciae and others ovate spots.

In that year it was found that the early migrants to cotton consisted of red individuals bearing fasciae and spotted individuals varying from yellow to orange in colour; the red spotted adults observed at the end of the previous season being absent. The differences in colour and marking of the two types of migrant were so well defined as to justify their being regarded as separate forms of *superstitiosus*; the names "banded" and "spotted" being adopted to denote the two forms, which do not interbreed. The predominance of red colouration at the end of the cotton season is due to the fact that adults of the generations derived from both yellow and orange migrants to cotton are almost invariably red in colour.

It is of interest that banded and spotted forms of *D. cingulatus* have been discovered in New Guinea,[1] the banded form preferring humid conditions. There are indications of a similar preference on the part of the banded form of *superstitiosus* in Nigeria.

* [Mr. W. E. China, of the British Museum, informs us that there are no specimens of *D. intermedius*, Dist., *D. nigrofasciatus*, Stål, or *D. migratorius*, Dist., from Nigeria in the British Museum, and that these species have probably been recorded on the evidence of wrongly determined specimens.—Ed.]

In September 1924 the stainer index, a standardised method of estimating stainer infestation on cotton,[2] was initiated, and data were obtained showing the weekly incidence of adults of the different species of *Dysdercus* on similar areas of Allen, Meko and Ishan cotton.

Index picking was applied to a block of Allen cotton containing plots sown on four different dates; the following table shows the number of adults of each form of *superstitiosus* occurring weekly on a representative area of ¾ acre, consisting of ⅜ acre sown on 15th July and of ⅛ acre sown on each of the following dates: 15th June, 1st July and 5th September.

TABLE I.

Week ending	Area in flower.	Spotted form.	Banded form.	Week ending	Area in flower.	Spotted form.	Banded form.
1924.				1924.			
Sept. 6th ...	⅛ acre	1	16	Dec. 6th ...	¼ acre	797	62
,, 13th ...	¼ ,,	4	28	,, 13th ...	¾ ,,	1,327	80
,, 20th ...	¼ ,,	4	30	,, 20th ...	¾ ,,	3,423	106
,, 27th ...	⅝ ,,	4	54	,, 27th ...	¼ ,,	2,238	90
Oct. 4th ...	⅝ ,,	10	51	1925.			
,, 11th ...	⅝ ,,	10	30	Jan. 3rd ...	¾ ,,	1,065	66
,, 18th ...	⅝ ,,	164	51	,, 10th ...	¾ ,,	947	92
,, 25th ...	⅝ ,,	289	43	,, 17th ...	⅝ ,,	789	113
Nov. 1st ...	⅝ ,,	384	38	,, 24th ...	⅝ ,,	641	136
,, 8th ...	⅝ ,,	744	69	,, 31st ...	⅝ ,,	465	134
,, 15th ...	¾ ,,	1,420	98	Feb. 7th ...	⅝ ,,	262	109
,, 22nd ...	¾ ,,	1,170	116	,, 14th ...	⅝ ,,	117	63
,, 29th ...	¾ ,,	744	74	,, 21st ...	⅝ ,,	91	63

It will be seen that the banded form was more numerous than the spotted in the first six weeks of the season; and that the spotted form increased rapidly in numbers in the period 12th October to 15th November. The first dates on which nymphs and newly-emerged adults appeared on the cotton were determined, and proof was obtained that the maxima on 15th November and 20th December represent respectively maximum migration of adults and maximum emergence of adults of the first filial generation produced on the cotton.

Similar maxima have been observed to occur in two subsequent seasons, although the dates on which they occur vary slightly from year to year. In each of three consecutive seasons the banded form has appeared on the cotton earlier in the season than the spotted form and has remained on the crop later. Many spotted adults migrate to *Sterculia* and *Bombax* in January, February and March; whereas the banded form remains on the cotton.

The reasons for the comparatively small fluctuations in the weekly incidence of the banded form have not been ascertained.

As stated in the preceding paragraph, many of the spotted form migrate to *Sterculia* and *Bombax* before the cotton is uprooted at the end of March. In April some banded adults migrate to these trees, and many are found in the vicinity of the cotton-fields feeding on stray cotton-seed and the seeds of other Malvaceae.

The banded form is more numerous than the spotted on standing cotton and all alternative food-plants (except Gramineae) from May to September. In October a sudden influx of spotted migrants takes place to cotton and maize. In November many adults of this form appear on guinea corn, *Hibiscus esculentus* and *H. sabdariffa*. The banded form is seldom seen on maize and guinea corn.

Throughout the 1924–25 season a record was kept of the colouration of all adults of the spotted form taken on the index plots. It was found that there is considerable variation in colouration among the migrants, several shades of yellow and orange being represented in addition to a definite red. Adults of all three colours were observed to pair indiscriminately in the field.

The following table shows the proportions of yellow, orange and red individuals collected, in periods of three weeks.

TABLE II.

Three weeks ending.	No. of adults collected.	Per cent. Yellow.	Per cent. Orange.	Per cent. Red.
1924.				
Sept.20th	30	90·0	10·0	0
Oct. 11th	106	90·6	8·5	0·9
Nov. 1st	3,502	82·7	16·0	1·3
Nov. 22nd... ...	7,476	66·7	31·3	2·0
Dec. 13th	7,560	8·1	18·1	73·8
1925.				
Jan. 3rd	9,351	0·8	6·7	92·5
Jan. 24th	2,988	1·3	7·7	91·0
Feb. 14th	1,545	1·0	4·4	94·6
Mar. 7th	311	0	3·2	96·8
Total No. collected	32,869	26·6	15·9	57·5

Newly-emerged spotted adults, red in colour, were first seen on 18th November, and no recently-moulted yellow or orange individual was found throughout the season in spite of the predominance of adults of these colours amongst the migrants. In the laboratory, generations of red adults have been reared from ova laid by both yellow and orange females, the food given being cotton-seed; and from a pair of red adults an F_1 generation of deep orange-red adults was obtained, both the F_1 and F_2 nymphs having been fed on *Hibiscus esculentus* seeds.

From 12th June to 24th October 1925, all adults and nymphs were collected, on six days a week, from a field of *H. esculentus* near Moor Plantation; and then once a week until the end of January 1926. In the following table is shown the number of yellow, orange and red adults collected each month.

TABLE III.

Month.	Yellow.	Orange.	Red.
1925.			
June	8	14	10
July	10	4	9
Aug.	6	2	0
Sept.	7	2	0
Oct.	10	7	0
Nov.	179		0
Dec.	0	0	0
1926.			
Jan.	0	1	3

In February, March and April 1927, systematic examinations were made of the adult stainers feeding on the seeds of *Bombax, Sterculia* and cotton in the bush about four miles west of Moor Plantation. The following table shows the colouration of adults of the spotted form collected.

TABLE IV.

Period.	*Bombax* sp.			*Sterculia* sp.			Native cotton.		
	Y.	O.	R.	Y.	O.	R.	Y.	O.	R.
1927.									
Feb. 9th to Mar. 5th ...	0	0	480*	0	0	12	0	0	31
Mar. 6th to April 28th ...	2	26	218	2	0	16	1	0	40

* About twenty individuals showed slight traces of orange.

In November 1924, a few of the F_1 individuals on Moor Plantation cotton were deep orange-red in colour, but at the end of the season the adults of this form showed no traces of orange, being as distinct a red as the banded form. On 10th November 1924, all the adults were collected from a small field of *Hibiscus esculentus* on Moor Plantation, there being a total of 153, of which 8 were banded and 145 were spotted (144 yellow or orange and 1 red). Nymphs of early instars were very numerous, and early in December a collection was made of fifth instar nymphs derived from those seen in November. From these were bred out 19 banded adults and 105 red spotted adults, no yellow or orange individuals being obtained. On 28th December 1926, a large number of fifth instar nymphs were collected from *Hibiscus sabdariffa* fruits in the field; and were given the same food in a cage in the laboratory. Between 30th December and 14th January, 78 red adults were bred out from these nymphs.

In conclusion, it seems probable that the colour variations of the spotted form are of seasonal rather than of dietetic origin, as red individuals have been reared on cotton, *Hibiscus esculentus* and *H. sabdariffa* in December; also field records at Ibadan show that yellow and orange adults preponderate from August to November, and red adults from December to May. At Kano (about 440 miles N.E. of Ibadan) approximately 50 per cent. of the migrants on cotton in September were found to be red in colour. There is a considerable difference in the climatic conditions prevailing at Kano and Ibadan.

2. *Dysdercus melanoderes*, Karsch.

In the following table is shown the weekly incidence of *melanoderes* adults on the representative $\frac{3}{4}$ acre of Allen cotton described in connection with Table I.

TABLE V.

Week ending	Numbers.	Week ending	Numbers.
1924.		1924.	
Sept. 6th	0	Dec 6th	83
,, 13th	0	,, 13th	135
,, 20th	2	,, 20th	419
,, 27th	1	,, 27th	478
Oct. 4th	2	1925.	
,, 11th	9	Jan 3rd	167
,, 18th	39	,, 10th	91
,, 25th	118	,, 17th	28
Nov. 1st	121	,, 24th	6
,, 8th	378	,, 31st	0
,, 15th	787	Feb. 7th	0
,, 22nd	451	,, 14th	0
,, 29th	118	,, 21st	0

It will be seen that the migration maximum synchronises with the respective maximum for the spotted *superstitiosus* shown in Table I, and that the F_1 adult emergence maximum occurs one week later than that of the spotted form.

There are considerable variations each year in the numbers of *melanoderes* occurring on cotton at Ibadan; to some extent these variations appear to be determined by the duration of rainless periods in July, August and September, *melanoderes* being rare in cotton seasons following a prolonged period with little or no precipitation in those months.

Table VI shows the correlation between "droughts" and the incidence of *melanoderes* on cotton for the last five seasons. The total number of adults taken in 20 consecutive weekly pickings from $\frac{1}{8}$ acre of Allen sown in July is utilised for comparative purposes; only observational evidence is available for the seasons 1922–23 and 1923–24.

TABLE VI.

Season.	No. of adults on $\frac{1}{8}$ acre in 20 weeks.	Remarks on incidence.	Duration of rainless periods.		Rainfall in inches.	
1922–23 ...	—	Rare	6 days	July 3–8	July 9	0·66
			6 ,,	,, 10–15	,, 16	0·02
			16 ,,	,, 17–Aug. 1	Aug. 2–5	2·38
			16 ,,	Aug. 6–21	—	—
1923–24 ...	—	Rare	6 days	July 28–Aug. 2	Aug. 3–5	0·22
			10 ,,	Aug. 6–15	,, 16	0·06
			7 ,,	,, 17–23	,, 24–26	0·20
			7 ,,	,, 27–Sept. 2	—	—
1924–25 ...	207	Medium	7 days	July 15–21	July 22–Aug. 8	1·50
			9 ,,	Aug. 9–17		
1925–26 ...	3,240	Very common	6 days	July 26–31	—	—
1926–27 ...	11	Very rare	7 days	July 26–Aug. 1	Aug. 2–4	2·09
			17 ,,	Aug. 5–21	,, 22–29	0·63
			6 ,,	,, 30–Sept. 4	—	—

Weekly atmometer readings are available for the period 30th August to 19th December in both 1924 and 1925; in twelve out of the sixteen weeks evaporation was lower in 1925 than in the corresponding weeks in 1924. A peculiar feature of the 1925–26 season was that, although *melanoderes* migrants were exceptionally numerous, very few F_1 adults were on the cotton in December.

Although there are very distinct indications that this species prefers humid atmospheric conditions, at Ibadan it is not numerous during the wet season. This may be acccounted for by a preference of *melanoderes* for the forest zone, as adults have been seen in thick secondary bush at Adio and in forest at Ilugun and Benin during the wet season.

3. *Dysdercus fasciatus*, Sign.

This species is rare at Ibadan, but in the more arid savannah country, about forty miles north, it is a cotton pest of some importance. At Ilorin, it is common on fallen fruits of the baobab (*Adansonia digitata*), although it is rarely found on cotton.

4. *Dysdercus haemorrhoidalis*, Sign.

This species is rare on cotton, but fairly common on *Bombax* in February and March ; it is found most frequently in the humid forest zone.

In a previous paper[7] it was mentioned that 14 specimens, believed to be *nigrofasciatus*, had been taken in 1923 ; the basis for this belief being the existence in the reference collection at Ibadan of a similar specimen which had been identified as *nigrofasciatus*, probably by a former entomologist in the Nigerian Agricultural Department. Since the publication of the paper mentioned above the writer has consulted Mr. W. E. China, of the British Museum, who has informed him that the species in question is *haemorrhoidalis*, Sign.

Lamborn[4] states that " the black-banded cotton stainer, *Dysdercus nigrofasciatus*, Stål, previously reported as a fairly abundant pest, did not appear until late December, and then only in very small numbers." From the apparently complete absence of *nigrofasciatus* during the last five years at Ibadan, it seems possible that the species referred to by Lamborn was either the black-banded *haemorrhoidalis* or the banded form of *superstitiosus*.

Relative Importance of the various Species of Dysdercus.

Table VII shows the number and percentage of adults of each species taken at Ibadan on $\frac{1}{8}$ acre of Allen cotton sown on 15th July in 20 weekly pickings between 12th September and 30th January in three seasons.

TABLE VII.

Species.	1924–25. Numbers.	1924–25. Per cent.	1925–26. Numbers.	1925–26. Per cent.	1926–27. Numbers.	1926–27. Per cent.
D. superstitiosus, spotted form ...	3,179	86·0	5,192	58·6	742	79·6
banded form ...	296	8·0	417	4·7	179	19·2
D. melanoderes	207	5·6	3,240	36·6	11	1·2
D. fasciatus	15	0·4	6	0·1	0	0

In the 1926–27 season only about two acres of Allen cotton were grown on Moor Plantation, and the numbers of stainers collected are not strictly comparable with those taken in the previous two seasons, although the specific proportions are unaffected.

It will be seen that the spotted form of *D. superstitiosus* is most numerous on cotton in the Ibadan district ; and evidence has been obtained that this form predominates on cotton at Ilorin, Oyo, Zaria and Kano ; *melanoderes* is of equal or greater importance in the forest zone at Ilugun ; and *fasciatus* is numerous at Oyo.

Notes on the Local Distribution of Dysdercus.

In 1924, Mason & Wright[6] carried out investigations on a number of cotton plots in savannah country near Oyo, about 40 miles north of Ibadan, and in the forest zone at Ilugun, about 20 miles W.S.W. of Ibadan.

In order to obtain comparative figures for the infestation of stainers on the various plots, Dr. Mason adopted the following picking method : Once a week four boys collected adults from one sixteenth of each of the one-acre plots for half an hour, different portions of the plots being selected each week.

The following table shows the incidence of the various species on July-sown Allen cotton in both localities, and evaporation from Livingston white spherical standardised atmometers in fortnightly periods.

TABLE VIII.

Locality.	No. of plots.	Species.	Two week periods ending 5th Nov.	19th Nov.	3rd Dec.	17th Dec.	31st Dec.
Oyo ...	4	**superstitiosus*	276	309	128	252	—
		fasciatus	0	90	149	138	—
Ilugun ...	2	**superstitiosus*	10	26	23	232	170
		melanoderes	106	248	44	28	7
			Evaporation in cc.				
Oyo ...			190	312	303	396	—
Ilugun ...			87	124	139	192	—

* Includes both forms ; counts made by the writer during November showed that the banded form was rarer at Oyo than at Ilugun in that month.

Dr. Mason's interesting figures show that *fasciatus* is abundant in the arid savannah country and *melanoderes* in the humid forest zone ; the writer has found only one specimen of *fasciatus* on cotton at Ilugun, and two of *melanoderes* on *Hibiscus vitifolius* at Oyo.

Other interesting features of the table are the abundance of *superstitiosus* at Oyo in October and November and the scarcity of that species at Ilugun in the same months.

At Ibadan, which is intermediate between these two localities in climatic conditions, *fasciatus* is rare and *melanoderes* varies very considerably in numbers from year to year.

In the 1925–26 season[3] two identical five-acre plots of cotton were planted, one on Moor Plantation and one in thick secondary bush at Adio (four miles west of the Plantation).

Table IX shows the number of adults of each species taken in 20 weeks on $\frac{1}{8}$ acre of each of the three varieties of cotton which comprised the five-acre plots.

TABLE IX.

Locality.	Variety of cotton.	Spotted *superstitiosus*.	Banded *superstitiosus*.	*D. melanoderes*.	*D. fasciatus*.	*D. haemorrhoidalis*.
Moor Plantation	Allen ...	5,192	417	3,240	6	0
	Meko ...	3,319	150	1,448	15	0
	Ishan ...	2,326	171	1,185	7	3
Adio	Allen ...	50	21	1,131	1	8
	Meko ...	27	24	303	0	5
	Ishan ...	88	64	384	0	4

The difference in the stainer population of two similar fields of cotton separated by a distance of only four miles are very striking ; it will be seen that *melanoderes* was numerous at Adio in spite of the plot being surrounded by thick secondary bush.

In the 1926–27 season Allen cotton was almost entirely replaced by indigenous varieties both on Moor Plantation and at Ilorin, only from one-half to two acres of exotic cotton being grown in each locality. Stainer index picking was carried

out by Mr. Lean at Ilorin[5] and by the writer on Moor Plantation, and in Table X is shown the number of adults of each species collected in 18 weeks on $\frac{1}{8}$ acre of each variety of cotton in the two localities. The comparatively small infestation on Allen cotton in both localities is due to the small area of that variety grown, the weekly index picking having a marked controlling effect ; therefore the Allen figures are only of value for comparison *inter se*.

TABLE X.

Locality.	Variety of cotton.	Spotted *superstitiosus*.	Banded *superstitiosus*.	*D. melanoderes*.	*D. fasciatus*.	*D. haemorrhoidalis*.
Moor Plantation	Allen ...	716	177	11	0	0
	Ishan ...	1,648	115	8	0	2
Ilorin	Allen ...	364	6	0	0	0
	Ishan ...	2,365	119	0	2	1
	Ilorin ...	2,750	191	0	6	0
	Kabba ...	632	42	0	2	1

It will be seen that no *melanoderes* adults were taken at Ilorin in the 1926–27 season. In the previous season the writer received several samples of stainers collected on cotton in that locality and found that this species was not represented in the samples.

Three samples of stainers, each containing about 50 adults, were received from Umuahia (about 275 miles south-east of Ibadan) and on examination were found to contain the following proportions of each species : December, 100 per cent. spotted *superstitiosus* ; February, 96 per cent. spotted, 3 per cent. banded, and 1 per cent. *fasciatus* ; March, 4 per cent. spotted and 96 per cent. banded.

In the forest zone of Benin Province (about 140 miles south-east of Ibadan) only 13 adult stainers were found between May and July, 1927 ; 9 were banded *superstiosus*, 2 spotted and 2 *melanoderes*. All the *superstitiosus* adults were found on cotton plants growing near native houses, and both the *melanoderes* individuals were seen in dense forest, one on the wing and one resting on foliage.

At Kano (about 440 miles N.E. of Ibadan) only the spotted form has been found, and at Zaria (about 360 miles N.E. of Ibadan) about 90 per cent. of the stainers found in September 1927 were spotted *superstitiosus*, the remainder being of the banded form.

From the rather scant data available it is concluded that both forms of *superstitiosus* are widely distributed in Nigeria, *melanoderes* is most numerous in the humid forest zone, and *fasciatus* in the savannah country near Oyo.

Observations on the Pairing of distinct Species of Dysdercus.

Only four cases of the pairing of adults of different species were observed in the field ; in two cases a female of *D. melanoderes* was found *in coitu* with a male of the spotted form of *D. superstitiosus*, and in two cases a male of *D. melanoderes* was found *in coitu* with a female of the banded form. The stainers collected during index picking in 1924 were brought from the field in wooden boxes, and on opening the boxes in the laboratory it was found that pairing of different species was not infrequent under these conditions. It should be emphasised that the crowded conditions existing in the collecting boxes were abnormal, and that the usually high proportions of

" natural " pairing indicate that copulation between different species and forms is rare in the field. The tendency to abnormal pairing under these conditions is exemplified by the fact that, on one occasion, a male of the spotted form was found *in coitu* with a female of the genus *Cenaeus* (PYRRHOCORIDAE).

The following table gives a summary of the pairing combinations recorded over a period of 15 weeks.

TABLE XI.

	Spotted *superstitiosus* ♂	Banded *superstitiosus* ♂	*D. melanoderes* ♂	*D. fasciatus* ♂
Spotted *superstitiosus* ♀ ...	3,176	0	7	0
Banded *superstitiosus* ♀ ...	17	710	16	0
D. melanoderes ♀	45	0	445	0
D. fasciatus ♀	0	1	0	38

The most salient features of the above table are the comparatively high percentage of female *melanoderes* pairing with males of the spotted *superstitiosus*, and the fact that banded males of *superstitiosus* were not found *in coitu* with females of either *melanoderes* or the spotted form.

Lamborn[4] reared eleven *superstitiosus* individuals from a cross between a male of that species and a female of *melanoderes* ; the rearing of a second generation from the progeny of a similar cross would be of extreme interest. The writer has made many attempts to cross these two species (and all combinations of species and forms), but in no case has even an F_1 generation been obtained, the ova produced being invariably infertile.

Duration of Development in Dysdercus.

In Table XII is shown the average duration, in days, of the various instars of three species of *Dysdercus* ; the food given being cotton-seed in each case.

TABLE XII.

	D. superstitiosus.		*D. melanoderes*	*D. fasciatus.*
	Spotted form.	Banded form.		
Incubation	5–6	5–6	5–6	6–7
1st instar	3–4	3–4	3–4	3–4
2nd ,, ...	5–6	4–5	3–4	4–5
3rd ,, ...	5–6	4–5	6–7	4–5
4th ,, ...	6–7	5–6	7–8	6–7
5th ,, ...	10–11	8–9	12–13	8–9
Egg to adult ...	34–40	29–35	36–42	31–37

The figures given for the spotted form may not be typical, as they were obtained from the observation of only two broods, it being found extremely difficult to rear

this form successfully under laboratory conditions. It will be seen that there are no striking differences in the length of the instar periods of the various species of *Dysdercus* when cotton-seed is utilised as food.

Migration to and from Cotton.

In a previous paper[2] the writer concluded that the migration of stainers to cotton was induced by the flowering of a large area, but diversity of planting dates greatly increased the difficulty of ascertaining whether there is a definite correlation between migration and flower production. Further data have been obtained, in various localities, and are tabulated below.

TABLE XIII.

Locality.	Year.	Week of maximum migration.	Week of maximum emergence of F_1 adults.
		Week ending	Week ending
Ibadan	1925	Nov. 7th	Dec. 19th
,, ...	1926	Oct. 28th	,, 23rd
Adio	1925	,, 31st	—— (few F_1 adults found).
Ilorin	1924	,, 19th (about)	Dec. 7th
,, ...	1925	,, 15th	,, 10th
,, ...	1926	,, 16th	,, 4th
Umuahia	1926	,, 28th	,, 9th
Makurdi	1926	,, 16th	Nov. 27th

In the five localities mentioned above, Allen cotton was sown between 14th and 17th July in each year for which data were available, and maximum flowering must have occurred about the middle of October, *viz.*, at, or shortly before, the time of maximum migration. It is evident, therefore, that migration to cotton is induced by the flowering of that crop. A period of about six weeks elapses between maximum migration and maximum production of adults of the first generation on the cotton.

There are considerable specific differences in the migration of stainers from the cotton crop, and it is necessary to deal with the principal species separately.

Dysdercus superstitiosus, spotted form.

Migration takes place in January, February and March, and in the Ibadan district is apparently induced by the flowering of *Bombax* and *Sterculia*.

It is possible that atmospheric conditions are, to some extent, responsible for the migration from cotton in January, as humidity is greater in the thick bush containing *Bombax* than on the cotton-fields at Ibadan. The spotted *superstitiosus* is rare on cotton at Ilorin, Oyo, and Ibadan in late December and January; and is rare at Adio and Ilugun in November, becoming more numerous in December and January. In the flight experiments, carried out in 1924, marked stainers were released north, south, and west of Moor Plantation; only individuals of the batches released to the north were recovered on the plantation cotton. These data give a slight indication that there is a tendency for stainers to migrate in a southerly direction, presumably, as a result of the arid harmattan wind from the Sahara. After October stainers are practically absent from cotton at Zaria and Kano in the Northern Provinces, where the harmattan is very severe; and Table XIII shows that maximum migration occurs earlier at Ilorin than in the more southerly localities.

Dysdercus superstitiosus, banded form.

As stated above, this form remains on the cotton longer than the spotted form, in fact, no evidence has been found of migration occurring prior to the uprooting of the cotton crop at the end of March.

Dysdercus melanoderes.

In 1925 adults of this species were unusually abundant on cotton at Ibadan and Adio (four miles west of Ibadan) in October and November and rare in December (a similar occurrence was observed by Dr. Mason at Ilugun in 1924, see Table X). Although fifth instar nymphs were common, very few F_1 adults were collected. No evidence has been obtained of excessive mortality occurring as a result of the aridity concomitant with the harmattan; or of *melanoderes* being a "wet season" form of *superstitiosus*. Therefore, it seems probable that *melanoderes*, which has been proved to favour the humid forest zone, migrates from the cotton in December when atmospheric conditions become too arid.

Phototropism.

From February to April, 1927, the writer obtained the co-operation of residents on Moor Plantation in the collection of stainers attracted to lights in the various bungalows. The results of this experiment are tabulated below.

Table XIV.

Date.	Number collected.	Species.
1927.		
Jan. 25th ...	1	Spotted *superstitiosus*
Feb. 19th ...	1	*D. haemorrhoidalis*
,, 23rd ...	1	Spotted *superstitiosus*
,, 27th ...	2	*D. haemorrhoidalis*
	1	*D. melanoderes*
Mar. 9th ...	1	Spotted *superstitiosus*
,, 10th ...	1	,, ,,
,, 21st ...	1	,, ,,
,, 29th ...	1	*D. haemorrhoidalis*
,, 30th ...	1	*D. melanoderes*
	2	Spotted *superstitiosus*
,, 31st ...	14	,, ,,
	1	*D. haemorrhoidalis*
Apr. 2nd ...	2	Banded *superstitiosus*

Most of the cotton on Moor Plantation was uprooted in the last week of March, and it will be seen that the majority of the stainers were caught after the uprooting of the crop.

The comparative abundance of *haemorrhoidalis* at light (observed also in 1923 and 1925) is remarkable in view of the rarity of this species on Moor Plantation cotton, and it seems probable that *haemorrhoidalis* is exceptionally phototropic.

Alternative Food-plants of Dysdercus.

The principal alternative food-plants of stainers in the Ibadan District are: *Bombax* sp., *Sterculia* sp., *Hibiscus esculentus*, *H. sabdariffa*, *Urena lobata* and *Abutilon zanzibaricum*. Generations have been bred on the seeds or fruits of all the plants in the laboratory. There are many foods of minor importance, *viz.*, the seeds of *Hibiscus rostellatus*, *H.* ? *cannabinus*, *H. vitifolius*, *Sida carpinifolia* and *Triumfetta rhomboidea*; the buds of *Hibiscus rosa-sinensis*; the fruits of *Elaeis guineënsis* and mango; the cobs of maize; the seeds of guinea corn and various grasses; dead animal matter and excrement.

In the Ilorin Province the seeds of silk-cotton trees, *Hibiscus esculentus*, *H. lunariifolius* and *Urena lobata* are the principal alternative foods.

The writer has been informed by Mr. G. S. Cotterell that *Adansonia digitata* is a very important food-plant in Togoland; but this tree is rare in the vicinity of Ibadan, and stainers have never been seen feeding on its seeds. At Ilorin only *fasciatus* has been found on *A. digitata*.

In the course of feeding experiments, carried out in 1923, it was found that the duration of post-embryonic development varies considerably according to the food given; and that the greatest variation occurs in the last nymphal stadium. A nymph fed on old seeds of *Bombax* took 38 days to complete this instar, and three nymphs fed on seeds of *Hibiscus rostellatus* died 21, 24 and 38 days respectively after they had completed their fourth ecdysis. In the case of stainer nymphs fed on cotton-seed the duration of the fifth instar averages 8 to 9 days and has not been observed to exceed 13 days.

Data on the incidence of the various species of *Dysdercus* on alternative food-plants are summarised in Table XV.

TABLE XV.

C=Common; R=Rare; X=Not seen.

	Spotted *superstitiosus*.	Banded *superstitiosus*.	*D. melanoderes*.	*D. haemorrhoidalis*.
Bombax sp. ...	C.	R.	R.	C.
Sterculia sp.	C.	R.	X.	X.
Hibiscus esculentus ...	C. (in dry season)	C.	R.	X.
H. sabdariffa ...	C.	C.	R.	X.
H. rosa-sinensis ...	R.	C.	C.	R.
H. vitifolius ...	R.	R.	R.	X.
Urena lobata ...	R.	C.	X.	X.
Abutilon zanzibaricum	R.	R.	R.	R.
Zea mays	C.	R.	X.	X.
Sorghum vulgare ...	C.	X.	X.	X.

D. fasciatus has been found only on cotton in the Ibadan district, probably on account of its general rarity in that locality; but at Ilorin it was found in numbers on fallen fruit of *Adansonia digitata* in September.

The most salient specific differences in the choice of food-plants are the preponderance of the spotted *superstitiosus* on Gramineae and *Bombax*, and of *melanoderes* on *Hibiscus rosa-sinensis*.

In July and August, 1927, Mr. O. B. Lean carried out stainer index picking on adjacent fields of bullrush millet and maize at Abagi in the Benue Province. In three weekly collections, between 1st and 21st July, 393 spotted *superstitiosus* and 2 of the banded form were obtained on $\frac{1}{8}$ acre of bullrush millet; and in four weekly

collections, between 15th July and 11th August, 159 of the spotted form were picked from $\frac{1}{8}$ acre of maize. The millet was harvested on 22nd July, and the stainers moved to the maize adjacent to the millet field.

Proportions of the Sexes.

During three successive cotton seasons a record was kept of the numbers of males and females of each species collected weekly on the index plots, with the exception of three weeks (6th to 26th December) in 1925.

In Table XVI are shown the weekly sex ratios (number of males per 100 females) and the number of individuals from which each ratio was calculated.

TABLE XVI.

D. superstitiosus, spotted form.

Week ending.	1924–25. No. collected.	1924–25. Ratio.	1925–26. No. collected.	1925–26. Ratio.	1926–27. No. collected.	1926–27. Ratio.
Oct. 11th ...	60	300	30	150	58	222
,, 18th ...	697	178	26	333	655	107
,, 25th ...	1,106	166	60	253	766	113
Nov. 1st ...	1,699	151	1,360	86	156	66
,, 8th ...	2,508	95	3,132	94	73	55
,, 15th ...	3,052	61	2,309	56	36	50
,, 22nd ...	1,916	69	348	18	38	90
,, 29th ...	1,337	75	157	55	36	140
Dec. 6th ...	2,481	98	208	145	114	90
,, 13th ...	3,742	101	—	—	371	125
,, 20th ...	4,837	102	—	—	452	122
,, 27th ...	2,796	94	—	—	222	87
Jan. 3rd ...	1,718	106	418	73	174	156
,, 10th ...	1,170	110	167	90	170	121
,, 17th ...	870	121	30	58	103	158
,, 24th ...	948	111	—	—	146	103
,, 31st ...	823	95	—	—	—	—
Feb. 7th ...	439	97	—	—	—	—
,, 14th ...	283	92	—	—	—	—
,, 21st ...	163	68	—	—	—	—
,, 28th ...	81	80	—	—	—	—
Mar. 7th ...	67	168	—	—	—	—

D. superstitiosus, banded form.

1924–25.			1924–25 (cont.).			1925–26 and 1926–27.
Sept. 6th ...	49	123	Dec. 13th ...	396	81	
,, 13th ...	88	115	,, 20th ...	330	83	Numbers too small to warrant calculation of sex ratios.
,, 20th ...	135	121	,, 27th ...	277	86	
,, 27th ...	231	103	Jan. 3rd ...	357	101	
Oct. 4th ...	190	96	,, 10th ...	396	93	
,, 11th ...	185	101	,, 17th ...	465	108	
,, 18th ...	400	105	,, 24th ...	613	93	
,, 25th ...	366	103	,, 31st ...	759	124	
Nov. 1st ...	312	105	Feb. 7th ...	623	131	
,, 8th ...	257	102	,, 14th ...	533	138	
,, 15th ...	296	86	,, 21st ...	356	120	
,, 22nd ...	234	86	,, 28th ...	310	105	
,, 29th ...	205	86	Mar. 7th ...	339	98	
Dec. 6th ...	323	70	—	—	—	

D. melanoderes.

	1924–25.		1925–26.		1926–27.
Oct. 4th ...	—	—	70	126	Numbers too small to warrant calculation of sex ratios.
,, 11th ...	25	92	437	134	
,, 18th ...	152	127	356	136	
,, 25th ...	273	117	315	113	
Nov. 1st ...	269	112	1,533	86	
,, 8th ...	642	87	1,557	98	
,, 15th ...	836	102	1,107	137	
,, 22nd ...	343	120	453	145	
,, 29th ...	104	96	147	67	
Dec. 6th ...	105	78	52	108	
,, 13th ...	130	69	—	—	
,, 20th ...	178	117	—	—	
,, 27th ...	173	84	—	—	
Jan. 3rd ...	94	88	49	113	

It will be seen that a rhythm exists in the weekly proportions of the sexes during the cotton season; males predominate amongst the early migrants and the first individuals of each generation to become mature. This rhythm appears to be the result of a shorter period of post-embryonic development in the case of males than in that of females derived from the same batch of ova, a supposition which has been corroborated by breeding experiments in the laboratory. Therefore, it seems probable that the early migrants to cotton are the first adults of a generation just commencing to become mature.

Owing to the colour variations of the spotted *superstitiosus*, it was possible to differentiate, with some certainty, between migrants and F_1 adults of this form; and it was found that there was a preponderance of males amongst the first F_1 adults on the cotton.

These well-defined fluctuations in the ratios have facilitated the determination of the causes of the variations in the incidence of *Dysdercus* on cotton at different periods during the cotton season.

In the following table are shown the sex ratios (males per 100 females) calculated from the total number of individuals of each species collected during three cotton seasons.

Table XVII.

Species.		1924–25.	1925–26.	1926–27.
D. superstitiosus, spotted form	No. collected ...	32,869	8,440	3,587
	Ratio	99	77	111
D. superstitiosus, banded form	No. collected ...	9,205	1,185	666
	Ratio	103	99	87
D. melanoderes	No. collected ...	3,412	7,939	28
	Ratio	100	110	—
D. fasciatus	No. collected ...	345	45	1
	Ratio	110	45	—

The sex ratios derived from the sum of the three-yearly totals are as follows: Spotted form 95, banded form 101, *D. melanoderes* 107, and *D. fasciatus* 100.

Summary and Conclusions.

(1) There are two forms of *D. superstitiosus*, F., in Nigeria, which are designated banded and spotted forms in the present paper. The banded form appears on cotton earlier in the season than the spotted, and it remains on the crop longer. Migration to cotton is gradual in the case of the banded form, while a sudden influx of migrants of the spotted form commences in October. Many spotted adults migrate to *Bombax* and *Sterculia* between January and March, whereas the banded form remains on the cotton until it is uprooted at the end of March. The spotted form is far more numerous than the banded on maize and guinea corn.

(2) There is considerable variation in the colouration of adults of the spotted form : at Ibadan about 99 per cent. of the migrants to cotton are yellow or orange in colour, while the adults of the filial generations produced on cotton are almost always red in colour (a few individuals are deep orange-red). These colour variations are thought to be of seasonal origin.

(3) *D. superstitiosus* is the most prevalent species on cotton at Ibadan, Ilorin, Oyo, Zaria and Kano ; *melanoderes* is of equal or greater importance in the forest zone at Ilugun and occasionally is numerous at Ibadan ; *fasciatus* is of importance in savannah country at Oyo ; *haemorrhoidalis* is rare on cotton. No evidence has been obtained that any one of these species is a varietal form of another species. Both forms of *superstitiosus* are widely distributed in Nigeria.

(4) Migration to cotton is induced by the flowering of that crop. The maximum weekly migration has occurred between the weeks ending 15th October and 7th November in five localities in the last three years ; *viz.*, at the time of, or soon after, the maximum flowering of the cotton crop. There are indications that there is a tendency for stainers to migrate in a southerly direction, probably as a result of the desiccating harmattan wind from the Sahara.

(5) The principal alternative food-plants of stainers in the Ibadan district are : *Bombax* sp., *Sterculia* sp., *Hibiscus esculentus*, *H. sabdariffa*, *Urena lobata*, and *Abutilon zanzibaricum*. At Ilorin, silk-cotton trees (*Bombax*), *H. esculentus*, *H. lunariifolius* and *U. lobata* are the most important alternative food-plants.

(6) A rhythm exists in the weekly proportions of the sexes during the cotton season ; males predominate among the early migrants to cotton and among the first individuals to mature of each generation. This rhythm appears to be the result of shorter period of post-embryonic development in the case of males than in that of females derived from the same batch of ova.

Acknowledgments.

In conclusion, the writer wishes to express his thanks to Mr. O. B. Lean for providing data obtained at Ilorin in 1926 ; to Dr. T. G. Mason for allowing him to make use of his 1924 Oyo and Ilugun figures ; to Dr. G. A. K. Marshall and Mr. W. E. China for identifying the local species of *Dysdercus* ; and to Dr. A. W. Hill for identifying many of the alternative food-plants.

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Mr. G. N. Wolcott :—42 Coleoptera ; from Haiti.

Mr. R. C. Wood :—1 Mantid and a Nematode parasite ; from Nyasaland.

THE EARLY STAGES OF SOME SINGAPORE MOSQUITOS.

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During the years 1925–7 an investigation was made of the Culicine mosquito fauna of Singapore, mainly with the object of learning which species were responsible for the local mosquito plague, and where they bred. In the course of this work numerous species were reared, the larvae of which have never been described, and descriptions of these are presented in this paper; these are supplementary to the descriptions published recently by Edwards (Bull. Ent. Res. xvii, pt. 2, 1926).

As a side-line of the work, a special investigation was made of the mosquito fauna of pitcher-plants. Large numbers of plants were examined, and many thousands of larvae found in them; the full list of mosquitos found in this habitat during the investigation is as follows :—

Anopheles sp. indet. Once only.
Megarhinus acaudatus, Leic. Frequent, but never more than one larva to a pitcher.
Uranotaenia brevirostris, Edw. Rather common.
,, *xanthomelaena*, Edw. Rare.
Rachionotomyia aranoides (Theo.). Very common.
,, *nepenthis*, Edw. Common.
,, *vicina*, Edw. Once.
Armigeres (*Leicesteria*) *flavus* (Leic.).
,, (*Armigeres*) *giveni*, Edw. Rather common.
,, ,, *malayi*, Theo. Once.
Culex (*Lophoceratomyia*) *navalis*, Edw. Common.
,, ,, *coerulescens*, Edw. Rather common.
,, ,, *eminentia*, Leic. Common.
,, ,, *hewitti*, Edw.
,, ,, *jenseni*, de Meij.
,, ,, *curtipalpis*, Edw.

Isolated larvae from pitcher-plants were found difficult to rear; the mortality was very high, and most of the species long-lived. Consequently most of the associations of larva and adult were made by examining the larvae first and putting together a number which appeared to belong to the same species, numbering each batch and the corresponding adults which hatched therefrom. The larvae were fed at intervals with insect debris from the pitcher-plants (which appeared to constitute a large part of their diet in nature) and in spite of care it was difficult to avoid introducing young larvae of other species with the food material. Both these possible sources of error of association were rendered almost negligible by the large amount of material dealt with.

After *Rachionotomyia aranoides*, which was by far the most abundant, the species of mosquitos most commonly met with were members of the subgenus *Lophoceratomyia* of *Culex*. These proved very confusing on account of the great similarity of the adults. It was not realised at first that there were no fewer than six species of this group, and that in three of them the male palpi are from half to two-thirds as long as the proboscis. All six larvae, however, are easily differentiated, and we believe we have now satisfactorily associated the adults with them.

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Two types of head were noticed among the pitcher-plant *Lophoceratomyia*. In three species the head is broad, like an ordinary *Culex*, with long curved antennae with large tuft, and long siphon; in the other three the head is smaller and more rounded, with shorter, straight antennae having a smaller tuft, and a shorter siphon, so that until closely examined these larvae are not recognisable as belonging to the *Culex* group. As mentioned above, the differences between the adults are rather obscure; the most important are to be found in the male hypopygium. None of these pitcher-plant species of *Lophoceratomyia* were found breeding in other situations, except that on one occasion a single larva of *C. hewitti* was found in a ground pool.

In the descriptions of larvae we have dropped the nomenclature of Lang for the hairs on the dorsal surface of the head, and used instead the following symbols for the five pairs of hairs of the clypeus:

A, outer post-antennal hair of Lang.
B, mid post-antennal hair of Lang.
C, inner post-antennal hair of Lang.
d, pre-antennal hair of Lang.
e, vertical hair of Lang.

Our reason for making this change is partly to economise space, but chiefly because Lang's nomenclature, proposed chiefly for *Anopheles*, does not apply at all well to Culicines, where the position of the hairs relative to the antennae varies greatly. The homology of the hairs, however, is usually obvious, except that where *B* and *C* stand directly one in front of the other it may not be obvious which is which; in such cases we call the anterior *B* and the posterior *C*. The position of hair *d* varies very greatly, and although it is often difficult to find owing to its small size, it is very useful for discrimination. We further prefer the term "clypeal spines" for the "pre-clypeal hairs" of Lang, as these are inserted on the front margin of the clypeus itself and are usually more or less spiny.

Uranotaenia obscura, Edw.

Larva.—*Head* about as broad as long, dark in colour. Clypeal spines well developed, but rather short and thick, placed upon small prominences, as usual in this genus. Of the slender dorsal hairs three pairs are placed in a slightly convex line near the front of the clypeus, the middle one of each three being forked near the base, the inner and the smaller outer hair simple; another moderately long and slender simple hair is placed behind these three, and the small posterior hair (*e*) is also simple; the arrangement of the hairs is somewhat as in *Aëdes albopictus*. Antenna short, cylindrical, slightly curved, the shaft bare except for a fine hair near the tip, bristles all apical and short. Mentum equilaterally triangular, teeth subequal and regular, about 9 on each side of the median tooth. *Thorax* without chitinous plates at bases of tufts. *Abdomen* with the lateral tufts of the first two segments 2-branched, remaining dorsal and lateral tufts mostly with 4–5 branches. Eighth segment with a large chitinous saddle, the usual lateral plates being connected across the dorsum of the segment. Comb-teeth 4–6 in number, sharply pointed and finely fringed at the base. Subsiphonal tuft rather large, 4-branched. *Anal segment* short, completely ringed by the plate, the hind margin of which is finely spinose. Inner and outer dorsal hairs both simple. Lateral hair strong, forked at base. Brush consisting of about four pairs of long single hairs, behind which are one or two pairs of small 2-to 3-branched tufts; no transverse bars. *Siphon* moderately dark, only slightly tapering, index about 1·7; acus well developed. Pecten variable; about 4–7 strong sharp-pointed simple teeth, sometimes extending well beyond middle of siphon; in other specimens not so far. Tuft small, 4-branched, placed a little beyond the middle of siphon and between the pectens.

Habitat.—Fallen leaves in jungle, in company with *Zeugnomyia gracilis* and *Aëdes jugraensis.*

Readily distinguished from other known larvae of this genus by the chitinous saddle of the eighth abdominal segment.

Zeugnomyia gracilis, Leic. (fig. 1).

Larva.—*Head* rather small and rounded, pale in colour. Clypeal spines long and bristle-like, the front margin of clypeus slightly emarginate between the bristles. Dorsal hairs small and placed far forward; *A*, *B* and *d* simple (*d* sometimes double), in a curved row in front of level of antennae, *C* simple, behind antennae; *e* small, double. Antennae short, cylindrical, smooth; a fine hair beyond mid-length; only three bristles present, which are all apical, the fourth bristle apparently represented by a small two-segmented papilla which is present in addition to the usual papilla. Mouth-brushes short but not specially modified, hairs very numerous. Mentum with about ten small rather blunt teeth on each side of a larger median tooth. Mandible with

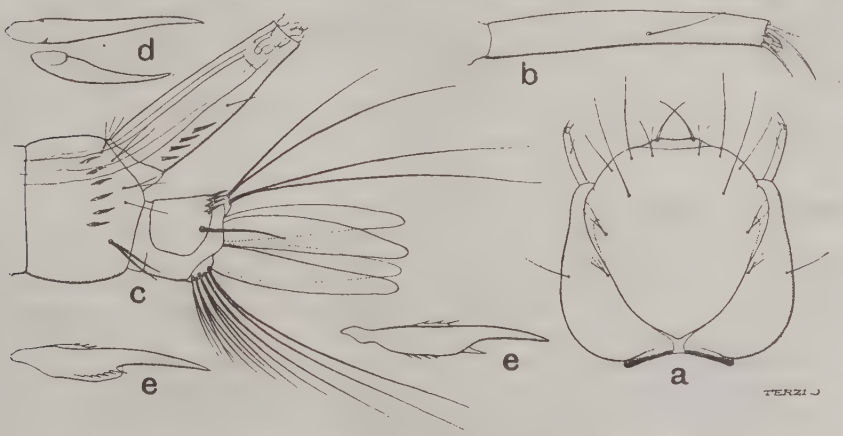

Fig. 1. Larva of *Zeugnomyia gracilis*, Leic.: *a*, head from above (mouth-brushes omitted); *b*, antenna; *c*, end of abdomen; *d*, pecten teeth; *e*, comb teeth.

strong black teeth; rather closely resembling that of *Sabethinus undosus* as figured by Howard, Dyar & Knab, except that the small basal hair-tuft is absent, and there is only one fringed bristle below the toothed portion instead of three. *Thorax* with 2 or at most 3 hairs in the lateral tufts, which have no associated spines. Prothorax with several lateral tufts but only one submedian tuft, which consists of one strong hair with two small basal branches. *Abdomen* with the lateral tufts on segments 1 and 2 triple; on 3–5 shorter, but each with four branches, stout and somewhat plumose; on 6 small and double. Dorsal hairs very small and inconspicuous. Eighth segment with the usual five lateral hairs; the lowermost of these is single (rarely double) and stout but rather short; the next three very minute, double; the uppermost larger but still inconspicuous and also double. Comb a rather irregular row of 6–7 strong, pointed, simple teeth; no plate. *Anal segment* with a moderately large saddle, the posterior margin of which bears 3–5 strong, sharp teeth and a stout single lateral hair. Outer and inner dorsal hairs both double and somewhat plumose. Brush consisting of a double row of hairs, four in each row, most of the hairs being double; no trace of transverse bars. Gills long and pointed, almost three times as long as the saddle. *Siphon* somewhat variable in shape, generally almost cylindrical

on basal half and rather strongly tapering on apical half, sometimes tapering almost from base ; index 3–3·5. Pecten composed of a rather oblique row of 3–6 strong, simple, pointed spines, extending only a short distance along the siphon. Tuft represented by a short single hair placed beyond middle of siphon. Valves small and normal in structure.

Habitat. Water collected in fallen forest leaves. The leaves are very large and leathery, sometimes two or three may be gummed together, and they always belong to the same species of tree. Two other species of larvae are always collected at the same time, *Aëdes jugraensis* and *Uranotaenia obscura*. The *Zeugnomyia* is predacious and lives on the other two species. When the water is emptied from the leaf the *Zeugnomyia* larvae hold on by their mouth-parts, unlike the other larvae.

As might have been anticipated from a study of adult morphology the larva of *Zeugnomyia* appears to occupy a somewhat intermediate position between the *Sabethes* and *Aëdes* groups of genera. It is not a true Sabethine, because the siphon lacks the scattered hairs which are present in the other genera of this group, but on the other hand the anal brush is much less developed than in *Aëdes*. This reduction of the brush, together with the reduction of the lateral tufts of the eighth segment, perhaps affords the readiest means for the identification of the larva of *Z. gracilis*. The structures at the tip of the antenna are similar to those seen in some species of *Uranotaenia*.

As the mouth-parts are not specially modified, it is probable that the larvae are not purely predacious.

Heizmannia funerea (Leic.)

Larva.—*Head* rounded, scarcely as broad as long, pale in colour except round occipital margin and mouth. Clypeal spines long and slender, not set on distinct tubercles ; a small accessory hair external to each. Dorsal hairs placed well back from the front ; *A* with about 15 plumose branches ; *B* with 2–3 branches, placed in front of but a little external to *C*, which has about 10 branches ; *d* smaller, but still rather large, with about 20 plumose branches arranged in a fan-shaped manner round a pear-shaped base ; *e* small, 2–3 branched. Antennae two-thirds as long as the head, somewhat curved and tapering, darkened on the outer half ; shaft with a few very fine spicules ; tuft of 4 branches placed about the middle ; preapical bristles close to tip, one much longer than the other. Mouth-brushes normal, the constituent hairs simple. Mentum triangular ; a rather large central tooth, on each side of which are first five closely set teeth, and then five more, shorter and more widely separated. *Thorax* with 3–4 almost simple hairs in the lateral tufts ; no associated spines, and no definite plates. *Abdomen* with the lateral hairs mostly double, dorsal hairs inconspicuous. Comb a patch of about 15 scales, most of which are finely and evenly fringed all round, though a few have a long terminal point. *Anal segment* with a moderately large saddle, the posterior margin of which is fringed with little clumps of very fine setae. Outer dorsal hair long and simple, inner dorsal hair double. Lateral hair rather long and simple. A small barred area present, with six long, double, non-plumose hairs ; two small single hairs before the barred area. *Siphon* very dark ; broadest a little before the middle, then rather strongly tapering ; index about 3. No acus. Pecten composed of 5–9 simple teeth, reaching hardly more than one-third the length of the siphon ; tuft represented by a single long hair placed a short distance beyond the last pecten tooth. Valves small, of normal structure.

Habitat.—Treehole, associated with *Ficalbia fusca*.

This is the first *Heizmannia* larva to be described. From the description it will be clear that it has all the essential features of *Aëdes*, so much so that it appears impossible to select any larval characters which may diagnose the genus.

The large and uniformly dark-scaled pronotal lobes of the adult appear to prove the identity of these specimens with *H. funerea* (Leic.). The male was hitherto unknown; it has the last two antennal segments very long, as in most of the other species; hypopygium very similar to that of *H. indica* (Theo.), but with slight differences in the clasper.

Pardomyia aurantia, Theo. (fig. 2).

Pupa.—Respiratory horns about half as long as the thorax; basal third or rather more blackish, as is the expanded tip, the rest pale and rather more slender. A small three-branched tuft behind the horn. First abdominal segment with a pair of large tufts; 2–7 with long single sublateral hairs, the other hairs inconspicuous; 8 with small 4-branched apical lateral tufts. Paddles rounded, without fringe; a small simple apical bristle; midrib strong.

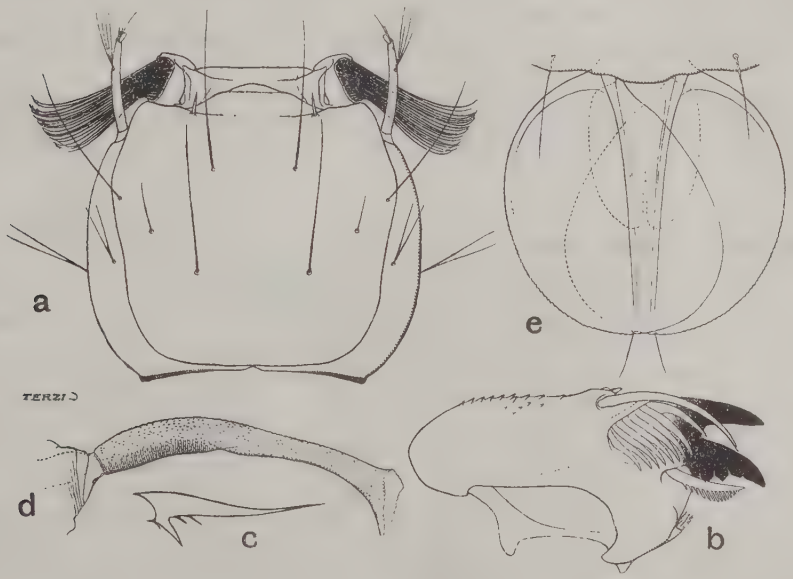

Fig. 2. *Pardomyia aurantia*, Theo.: *a*, head of larva from above; *b*, mandible of larva; *c*, pecten tooth; *d*, respiratory horn of pupa; *e*, pupal paddles.

Larva, fourth stage.—Head almost rectangular, slightly broader than long, pale in colour. Mouth-brushes forming matted tufts, evidently modified for prehension; mandibles large, with very strong black teeth, below which is a curious fringed spine; maxillae much as figured by Howard, Dyar and Knab for *Aëdes mediovittatus*. Clypeal spines short, very widely separated, placed further back than usual and therefore not easily seen. Dorsal hairs all simple and not very long. Antennae scarcely half as long as head, slender, slightly curved and tapering; shaft almost smooth; a small 4-haired tuft on the outer side at three-quarters of their length; bristles all small and apical. Mentum rather broad and short; a large trifid central tooth and about four or five others on each side. *Thorax* with the lateral tufts short but many-branched, set in small plates without spines; in addition some longer single hairs. The tracheal trunks have large bladder-like swellings in the thorax, recalling those of *Taeniorhynchus*. *Abdomen*: segment 1 with a 6-haired plumose tuft and a long single hair on

each side ; 2 similar, but the tuft 10-haired ; 2–7 each with the lateral hair double, dorsal hairs feebly developed ; 8 with three moderately large many-branched lateral tufts. Comb a patch of about 20 simple sharp teeth. *Anal segment* with very large plate forming almost a complete ring, its posterior margin smooth. Outer and inner dorsal hairs both long and simple. Lateral hair simple, moderately long and slender. Brush large, with about 16 tufts, each with about 10 branches on a somewhat curved stem; in addition there are 5 or 6 similar but smaller tufts in a row before the barred area. *Siphon* not very dark, moderately tapering, index about 2. Acus well developed. Pecten composed of about 20 rather close-set teeth, each with 2–5 denticles on one side near base, the last tooth just beyond middle of siphon. Tuft of about 6 hairs placed just beyond and inside end of pecten.

Larva, third stage.—Similar to the fourth stage larva, except that the head is darker (except towards front), the siphon darker (except towards tip) and rather shorter, the anal plate does not extend so far down the sides of the segment, the thoracic tufts have fewer branches.

Habitat.—Pot-holes in mangrove, in company with *Aëdes umbrosus*, on which it fed.

Except for the obvious modification of the mouth-parts for predacity, this larva has all the characters of *Aëdes*. The chitin of the head, siphon, and anal segment has the fine ridging more marked than usual, giving it a very scaly appearance under a high power.

Armigeres (Leicesteria) flavus (Leic.) (fig. 3).

Larva. *Head* much as in the other species of the genus ; roundish in shape and pale in colour. Clypeal spines hair-like but set on large tubercles. Dorsal hairs placed far forward; *a* placed nearest the front, dendriform, with about 8 branches; *B* simple or two-branched ; *C* placed obliquely behind *B*, 3–4-branched, both rather small. Antennae nearly cylindrical, smooth, with a fine hair at one-third of their length. Mentum rather broad, with about five teeth on each side of the triple median tooth. *Thorax* with not more than two simple hairs in any of the lateral tufts, which are set in distinct chitinous plates that have no trace of a projecting spine. *Abdomen* with all the hairs of segments 1–7 simple except the two lateral hairs of the first segment and the dorsal hair of the 7th, which are double ; the dorsal hairs are almost as long and thick as the lateral hairs. Eighth segment with one strong lateral tuft composed of 5–8 stout simple branches and set in a small plate ; other four hairs of eighth segment small, each with several branches. *Comb* of about 10 small scales in a patch ; each scale has a pear-shaped base, the free portion being divided to the base into 3–5 portions, each of which is irregularly frayed towards the tip. *Anal segment* with two chitinous plates, one dorsal and the other ventral, the dorsal plate larger than the ventral and extending below the middle, not quite meeting the ventral plate. Outer dorsal hairs are two or three-branched, inner 3–5-branched, both slightly plumose. Brush composed of five pairs of double (rarely triple), slightly plumose hairs, the usual chitinous transverse bars hardly indicated. A very small branched lateral hair set between the plates. Gills very stout, round-ended, over twice as long as the saddle. *Siphon* moderately dark, tapering, index about 1·0 ; without pecten but with a small two-haired tuft at four-fifths of its length. No acus. Tracheae very large, with numerous perforations near base of siphon.

Habitat.—Pitcher-plants. The species is common in jungle at Singapore and it must have other breeding places. Leicester recorded it from a bamboo and a coconut shell ; in the adults there appear to be no differences between those from Singapore and those from the peninsula.

A unique feature of this larva, found in no other mosquito larva hitherto known, is the presence of a ventral chitinous plate on the anal segment. The comb-teeth are of unusual form, but the remaining characters are similar to those of other *Armigeres* larvae.

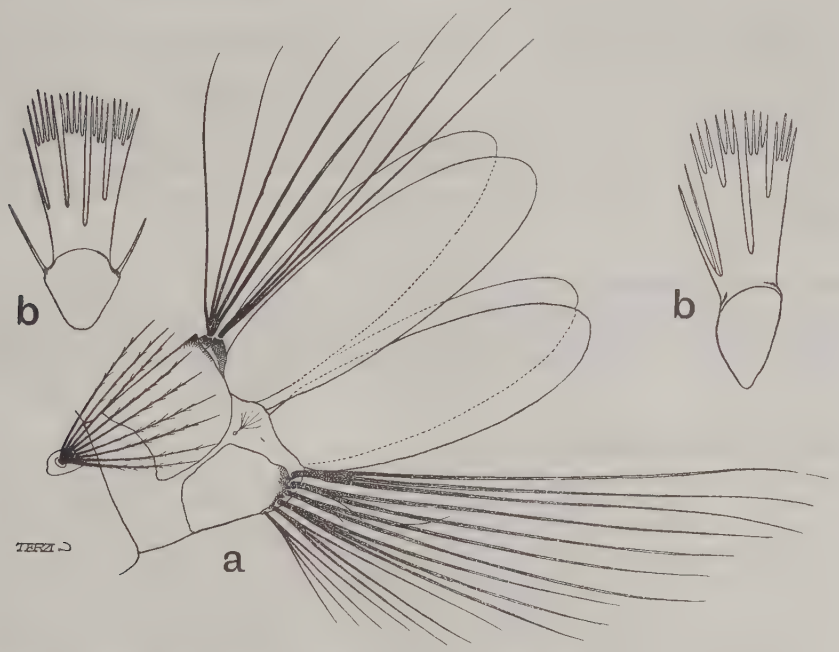

Fig. 3. Larva of *Armigeres flavus* (Leic.) : *a*, anal segment and tuft of eighth segment; *b*, comb scales.

Aëdes (Finlaya) jugraensis (Leic.).

LARVA.—*Head* rounded, not very dark. Hairs *A*, *B* and *C* placed well forward, all in front of the level of the antennae, especially *B* and *C*, which are side by side though well apart ; *A* and *C* each with four simple branches, *B* with three ; *d* not traceable ; *e* simple. Antennae about half as long as the head, almost smooth, scarcely curved and rather slender ; a small two-haired tuft placed a little beyond the middle. Mentum triangular ; central tooth rather large, with about 8 smaller closely set teeth on each side, and outside these 3 or 4 more, shorter, widely spaced teeth. *Thorax* with the lateral tufts plumose, those of the meso- and metathorax set in rather large dark plates, the two lower plates each with a rather long spine. Upper tuft of metathorax very short, its three branches very stout and almost spine-like. Dorsally at about the junction between the meso- and metathorax is a pair of stout almost spine-like plumose bristles. *Abdomen* with the lateral hairs of segments 1 and 2 set in small plates, each plate bearing a double plumose hair above and a single one below ; on segments 3–5 the lateral hairs are triple and on 6–7 double. Dorsal hairs not unusually large. Subsiphonal tuft of eighth segment large, with about 6 branches. Comb a patch of about 20 simple sharp-pointed teeth. *Anal segment* with the dorsal plate bordered posteriorly with small teeth, as usual in this subgenus ; lateral hair single, slightly plumose, a little longer than the plate. Brush comprising about 12

large tufts, none before the barred area. *Siphon* black, strongly tapering from the base, index rather under 2; acus well developed. Pecten of 12–14 teeth, each of which bears a strong denticle some distance from the base and some small denticles (not always clearly visible) at the base; the teeth forming a regular close-set row extending half the length of the siphon. Tuft of 5–6 plumose branches placed at level of, and between ends of pectens.

Habitat.—Fallen forest leaves, in company with *Zeugnomyia gracilis* and *Uranotaenia obscura*.

The larva differs markedly from that of the allied *A. chrysolineatus*, Theo. (described by Barraud, Ind. Journ. Med. Res., xi, p. 500, 1923, as *Finlaya trilineata*) in the shorter pecten without simple teeth at the tip, and probably also in the thoracic tufts and plates, which are not fully described by Barraud. The thoracic structures are subject to great variation in this subgenus and provide the readiest means of distinguishing many of the species.

Aëdes (Finlaya) saxicola, Edw.

Larvae were found in rock pools at Pulai Oban, Singapore, in company with *Culex* (*Lophoceratomyia*) *minor*, Leic. They are quite similar to those of *A.* (*F.*) *greigi*, Barr., described from Assam, except that the siphon is rather more slender (index 3 instead of 2·5).

Aëdes (Aëdimorphus) orbitae, Edw.

Larva. Very similar to that of *A. caecus* (Theo.) as described by Brug (Bull. Ent. Res., xiv, p. 436, 1924), the chief differences being as follows: Siphonal index about 4 instead of 2·8. The three or four simple detached pecten teeth are not much larger than the others and are less widely spaced. Instead of a single patch of fine bristles on the anterior surface of the siphon placed just before the end of the pecten, there are two similar patches, one on each side just beyond the pecten. The small spines at the tip of the siphon do not form a complete collar as in *A. caecus*, but are confined to the anterior surface, where they extend further down from the tip than in *A. caecus*. Anal gills very long and pointed, almost equalling the siphon in length.

Habitat.—Cart-tracks in jungle at Gunong Pulai.

Aëdes (Aëdes) cyrtolabis, Edw. (fig. 4, *c*, *d*.)

Larva. Head broader than long, rather dark except towards front. Clypeal spines long and slender, accessory hairs minute. Dorsal hairs placed well back; *A* with about eight branches; *B* and *C* placed well apart and one directly in front of the other, three-branched; *d* very small, five-branched, placed far forward. Antennae over half as long as the head, slightly tapering, curved, spicular; tuft of 4–5 hairs just before middle; bristles all apical, one long and three short; papilla rather short and stout. Mentum triangular; median tooth rather small, with about 20 still smaller teeth on each side. *Thorax* with large lateral tufts with 6–8 branches; no spines. *Abdomen* with lateral hairs of first segment double, those on 2–7 single; 8 with three conspicuous lateral tufts each with 6–8 branches. Comb a single row of 6–8 sharp-pointed, finely fringed scales. *Anal segment* with large chitinous plate forming an almost complete ring, its posterior edge smooth. Lateral hair simple and rather small. About 10 tufts in the brush, 8 in the barred area and 2 before it, each tuft with about 8 branches. Gills very long, over three times as long as the plate. Outer dorsal hair simple as usual, the inner shorter and with about 6 branches. *Siphon* moderately dark, slightly broadened to near middle, then tapering; index

about 2·2; acus rather broad. Pecten reaching a little beyond middle of siphon; about 12 teeth, most of which have one or two strong basal denticles, the last three rather stronger and more widely separated, without denticles. Tuft small, about 4 branches, placed in line with pecten a short distance beyond the last tooth.

Habitat.—Mangrove area.

This is the first species of this group whose larva has been described. Although similar in many respects to *A. cinereus*, Mg., it differs in the arrangement of the dorsal line of the head.

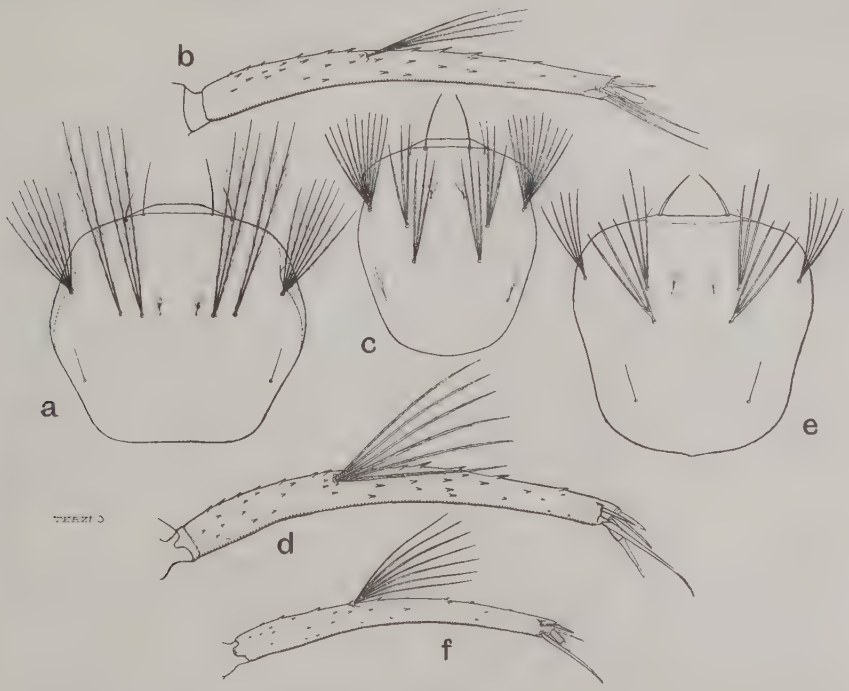

Fig. 4. Clypeus and antennae of larvae of *Aëdes*: (*a*, *b*), *A. curtipes*, Edw.; (*c*, *d*) *A. cyrtolabis*, Edw.; (*e*, *f*), *A. umbrosus*, Brug.

Aëdes (Aëdes) umbrosus, Brug (fig. 4, *e*, *f*).

Larva. *Head* broader than long (55·40), mostly pale, but darkened behind. Antenna a little over half as long as the head, shaft with a few fine spicules, very slightly tapering; tuft of moderate size, composed of 4–5 simple hairs and placed a little before the middle; preapical bristles very close to tip, one long and stout, the other very short; apical bristles both rather short; papilla stout and not very long. Clypeal spines rather short and thick. Tufts *A*, *B* and *C* composed of simple hairs, rather stout but not long; *A* with 5–6 branches; the others with 2–3 each, and arranged almost in a rectangle, as in the subgenus *Ochlerotatus*; *d* very small and fine, with several branches, not so far forward as in *A. cyrtolabis*. Mentum triangular, with about 12 teeth on each side of the median tooth, which is not much larger than the others. *Thorax* with the lateral tufts large and composed of slightly plumose

hairs ; no distinct spines. *Abdomen* with the lateral tufts single except on the first two segments, where they are double. Four branched lateral tufts on eighth segment, two of them large and composed of 6–8 plumose branches. *Comb* a single rather irregular row of about 8 large but simple and blunt-ended teeth. *Anal segment* with large saddle forming a nearly complete ring. Brush with eight rather large tufts in the barred area, three small ones before it. Lateral hair rather long and simple. Gills moderately long. *Siphon* rather dark, not strongly tapering, index about 1·8–2 ; acus distinct, somewhat oval. Pecten with 9–12 teeth, rather closely set and reaching a little beyond middle of siphon ; teeth long, pointed, with one or two small basal denticles. Tuft moderate, with 4–5 hairs, in line with pecten and placed well beyond the last tooth. Valves small.

Habitat.—Pot-holes and crab-holes in uncut mangrove.

Aëdes (Skusea) curtipes, Edw. (fig. 4, *a*, *b*).

Larva. *Head* large, much broadened behind and distinctly broader than long, pale in colour. Antennae almost as long as the head, shaft with numerous spicules ; tuft placed just before middle and composed of 5–6 slightly plumose branches which reach tip of antenna ; one of the two subapical bristles and one of the two apical bristles long (about a third as long as antenna) the other two short ; papilla long and pointed. Clypeal spines long, bristle-like ; a short hair external to each. Tufts *A*, *B* and *C* large, plumose, with 7–10, 2 and 3 branches respectively ; *d* very small and fine, with about 6 branches ; *e* simple. *A*, *B* and *C* in a slightly curved line, *B* and *C* rather close together. Mentum rather large, triangular, with about 15 teeth on each side of the larger median tooth, the last three or four teeth on each side shorter and more detached. *Thorax* with the lateral tufts large and plumose ; associated spines very short. *Abdomen* with the lateral tufts two-haired, those on the first two segments plumose ; remaining hairs inconspicuous. *Comb* with about 70 long and narrow, sharp-pointed, simple teeth. *Anal segment* with small saddle. Brush with about 8 tufts, borne on rather long stems ; none outside the barred area. Gills short, somewhat pear-shaped, upper pair almost as long as the saddle, lower pair shorter. *Siphon* not very dark, rather strongly tapering on the outer half, index about 2·7 ; acus distinct, narrow. Pecten composed of 6–8 teeth, mostly rather widely spaced and extending a little beyond middle of siphon ; teeth with two or three very strong sub-basal denticles, the first of which is almost as long as the tooth itself. Tuft small, with 3–5 hairs, placed in line with pecten well beyond the last tooth. Valves small.

Habitat.—Mangrove pot-holes.

As compared with other species which have been placed in the subgenus *Skusea*, the larva of *A. curtipes* resembles that of *A. longirostris* in many respects, but differs very obviously in the small siphonal tuft, smaller number of pecten-teeth which have much stronger denticles, and in other details. In spite of the great difference in the male hypopygium it seems clear that these species are somewhat nearly related.

Taeniorhynchus (Mansonioides) uniformis, Theo. (fig. 5, *b*).

Larva, fourth stage.—Extremely similar to that of *T.* (*M.*) *africanus*, Theo., described by Ingram (Bull. Ent. Res., iii, p. 76), the following points among others being common to the two species : Shaft of antenna wholly rigid, divided into three portions of almost equal length by the tuft and the subapical bristles, the latter both very long and projecting far beyond end of antenna. Clypeal hairs *B* and *C* absent. Thoracic tufts only moderately long, the pair near middle of prothorax not reaching front of head. Comb consisting of only 2–3 teeth, which are blunt-ended. Anal segment with 4–5 small tufts piercing the plate before the barred area. Siphon

without a distinct dark ring at the base. The only point which clearly differentiates. *T. uniformis* is the form of the subsiphonal tuft of the eighth segment, which in all the specimens examined is moderately large and two-haired; in *T. africanus* it is smaller and three- or four-haired.

LARVA, third stage.—Differs from the full-grown larva in the following particulars: Anal segment with a dorsal plate only, not a complete ring; the small tufts before the barred area represented by single hairs. Siphon considerably longer, index about 1·5 (excluding valves); basal half (again excluding valves) much darker than apical, but without a sharp line of demarcation. Siphonal tuft a single hair, instead of with 2–3 branches. Valves relatively shorter, with less perfect serrations.

PUPA.—Quite similar to that of *T. africanus*; abdominal segments 2–7 each with four strong bristles on the hind margin, respiratory horn rather long, the terminal chitinised spine being about one-third of the total length, its margin smooth (in pupae of *T. richiardii*, Fic., the lateral flanges of this spine have a feathery appearance owing to transverse ribbing).

Habitat.—A grassy swamp in a bay of the Kalang Reservoir. The grass grew in a thick mat which completely concealed the water from view. The water was several feet deep in places, but so strong was the mesh that one could walk across without actually touching bottom. The water exposed in foot-marks looked very foul and was covered with a thick scum which appeared to be iron. It is of interest to note that both in this species and in *T. africanus* cast pupal skins show the respiratory horn entire, the tip not being broken off as it is in *T. richiardii* (recorded in Ent. Mo. Mag., v, p. 87, 1919). This is evidently to be explained by the fact that the tip of the horn in these two species, being smooth, is readily withdrawn from the roots.

Larvae and pupae were kept under observation in a large bowl in which water grass from the swamp was planted. The grass flourished and provided a good medium for rearing *T. uniformis*, a number of adults of which were obtained. Both larvae and pupae were observed to move about; on one occasion two pupae were seen with all four breathing tubes inserted into one hole in a grass-root.

Taeniorhynchus (Coquillettidia) sp. (fig. 5, *a*).

LARVA. fourth stage.—Extremely similar to *T.* (*C.*) *richiardii*, Fic., described by Wesenberg-Lund (Vid. Medd. lxix, pp. 277–328, 1918) and *T.* (*C.*) *perturbans*, Walk., described by Howard, Dyar and Knab; the following points among others are common to the three species: Shaft of antenna rigid as far as the pre-apical bristles, which are both short, one being shorter than the other. Beyond this point the antenna is flexible, and the length of this apical portion of the antenna is greater than that of the basal portion; under a high power this slender apical portion of the antenna appears finely ribbed transversely owing to irregular chitinisation; on its outer face there is a continuous "backbone" of chitin, but the inner face is partly membranous. Clypeal hairs *B* and *C* well developed, each with about 6 branches. Thoracic tufts large, the pair near middle of prothorax very long and extending beyond front of head. Tip of antenna with a short but strongly chitinised bristle which has a curious bulbous and membranous base, also another very short pale bristle, and the usual papilla. Comb consists of a transverse row of sharp teeth. Anal segment without any small ventral tufts before the barred area. Siphon with a dark ring at the base, separated from the apical part by a distinct line.

Distinctions from *T. richiardii* and *T. perturbans* are the following: Comb-teeth fewer in number (5–8 instead of about 12) and larger. Sub-siphonal hair of eighth segment very long, single, but somewhat plumose apically (in the other two species it is shorter, with 2–3 simple branches).

LARVA, third stage.—Antenna rather shorter (relatively) than in the full-grown larva, the slender terminal portion only about as long as the basal part. Anal segment with dorsal plate only. Siphon considerably longer than in the full-grown larva, the dark basal portion occupying about half the length (excluding the relatively shorter valves) but separated from the apical portion by a slight circular constriction.

Habitat.—Grassy swamp in company with *T. uniformis*. No adults were reared, although larvae were kept under observation in a large bowl together with those of *T. uniformis*, and under these conditions the latter species hatched readily. Traps were also placed over the breeding-ground, but again the only species obtained was *T. uniformis*. The larvae described above are therefore undetermined, but are probably either *T. brevicellulus*, Theo., or *T. ochraceus*, Theo., both of which were found to be common at Singapore.

The long slender antennae were observed to have a prehensile function, an observation which has not been made regarding any other larvae of the subgenus, although it is supported by the microscopic structure of the antennae, the mode of chitinisation of the terminal tubular portion evidently allowing it to be curled inwards; the peculiarly modified terminal bristle also indicates a change of function.

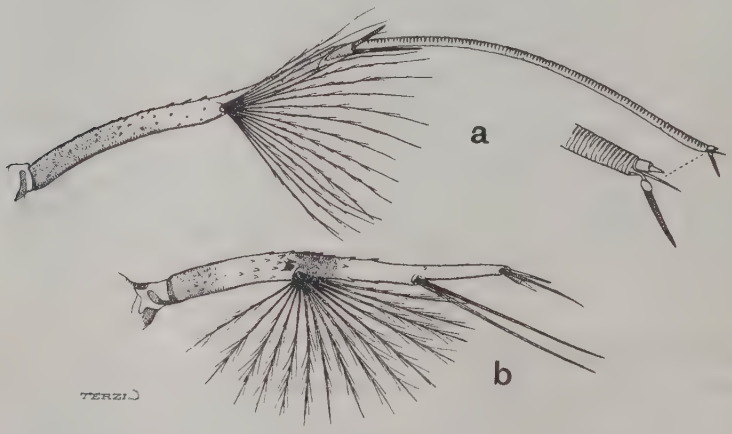

Fig.5. Antennae of larvae of *Taeniorhynchus*: (*a*), *T.* (*Coquillettidia*) sp.; (*b*), *T.* (*Mansonioides*) *uniformis*, Theo.

The discovery of larvae of this species and *T. uniformis* enables us, on comparison with the other known species, to indicate characters which are probably of subgeneric value and to confirm the separation of the adults of the genus *Taeniorhynchus* into three subgenera; the larval distinctions appear to be as follows:

1. Head with hairs *B* and *C* well developed; no ventral tufts outside brush of anal segment; last section of antenna long and slender.
   Subg. *Coquillettidia*, Dyar.
   Head with hairs *B* and *C* minute or absent; several small ventral tufts outside brush of anal segment 2
2. Last section of antenna, beyond subapical bristles, long and slender, comprising half the total length ... ... Subg. *Taeniorhynchus*, Arr., s. str.
   Last section of antenna shorter, less slender, comprising at most one-third the total length ... ... Subg. *Mansonioides*, Theo.

Mimomyia metallica (Leic.).

Pupa.—Respiratory horns long and slender, almost as long as the whole thorax; basal four-fifths black, with the usual spiral thickening; end fifth whitish, the tip somewhat darkened, with almost circular opening. The thorax has a conspicuous colour pattern composed of a number of narrow dark brown lines which commence near the base of the horn and extend longitudinally across the wing-pads and leg-sheaths; in addition there is a blackish mark on the front of the thorax between the horns, and the antennal sheaths have numerous transverse brown bands. Tuft of first abdominal segment very poorly developed. Sublateral tufts of 2–7 each with about 4 branches; lateral tufts of 8 broken. Paddles about 1·5 times as long as their greatest breadth, mainly dark in colour, but with a large whitish area occupying the basal two-thirds of the outer margin; midrib strong; no terminal hair, but the margin with about 20 small spines, extending for some distance round the tip.

Larva.—Very similar to that of *M. chamberlaini*, Ludl., described and figured by Barraud (Ind. Journ. Med. Res., xi, p. 504, 1923), differing chiefly as follows: Antennae entirely black, the tuft placed a little beyond the middle. Comb teeth rather more numerous and arranged in a patch, not a transverse row. Spines on posterior margin of anal plate forming a more regular row. Siphon somewhat more curved and tapering on the outer half, the tip hardly more than half as wide as the base. In both species one pair of siphonal valves bears a long fine hair quite half as long as the siphon itself; this hair is not well shown in Barraud's figure.

Habitat.—Grassy swamp along Kalang Reservoir, in which *Taeniorhynchus uniformis*, Theo., was also found. *M. metallica* was the only species found in the drier parts of this swamp, where it occurred in large numbers.

Mimomyia sp.

Larva.—Differs from *M. metallica* as follows: Head pale in colour instead of black. Antennae entirely pale, the spicules weaker. Clypeal spines with a short branch at the base on each side. Comb teeth in a regular transverse row. Siphon slightly broadened towards the middle, then much tapering, the tip curved forwards, its diameter only about one-third that of the base. Tuft two-haired. Valves very small, apparently without long hair.

A single larva, unfortunately not reared. Adults of *M. minima* (Leic.) were collected, and it is probable the larva belongs to this species. No other member of the genus has been found at Singapore.

Ficalbia fusca (Leic.) (fig. 6).

Pupa. Has much resemblance to that of *F. mediolineata* (Theo.), described by Macfie and Ingram (Bull. Ent. Res., vi, p. 423, 1923) and *F. luzonensis* (Ludl.) described by Senior-White (Ceylon Journ. Sci., B. xiii, p. 220, 1925). *Respiratory horns* extremely long and slender, the basal four-fifths or thereabouts black, the end fifth white. In the black portion the internal spiral thickening is not conspicuous, but the surface is densely covered externally with minute bristles; the white portion is bare, and shows two false joints or lines of weakness; opening small and almost circular. Below the horn is a long bristle, and behind it is a shorter stout spine-like bristle, much stronger than a similar bristle which occurs in *F. luzonensis*. *Abdomen* without tuft on the first segment, but with eight strong black bristles directed forwards. Segments 2–7 with the lateral and dorsal hairs very small, but with two long and strong sublateral bristles on each side, each being forked at base but non-plumose. Segment 8 with the apical tufts very large, with about 12 plumose branches, the branches all arising from the base. Paddles extremely narrow, almost linear, with serrated edges, the serrations stronger on the inner edge.

Larva. *Head* pale, somewhat broader than long. Clypeal spines long; no accessory hairs. Tufts *A*, *B* and *C* very large, plumose, *A* and *C* with 25 or more branches, *B* with about 12 branches; *B* and *C* placed almost side by side and rather close together; *d* small, branched at some distance from base. Antennae almost as long as the head; shaft rather stout, with numerous fine hairs on the basal portion which are only visible under a high power; tuft very large, with about 20 plumose branches, placed at about one-third the length of the shaft. Subapical antennal bristles very long and placed a little beyond two-thirds, of very remarkable dendritic form; some distance from the base each of the pair splits into about five branches,

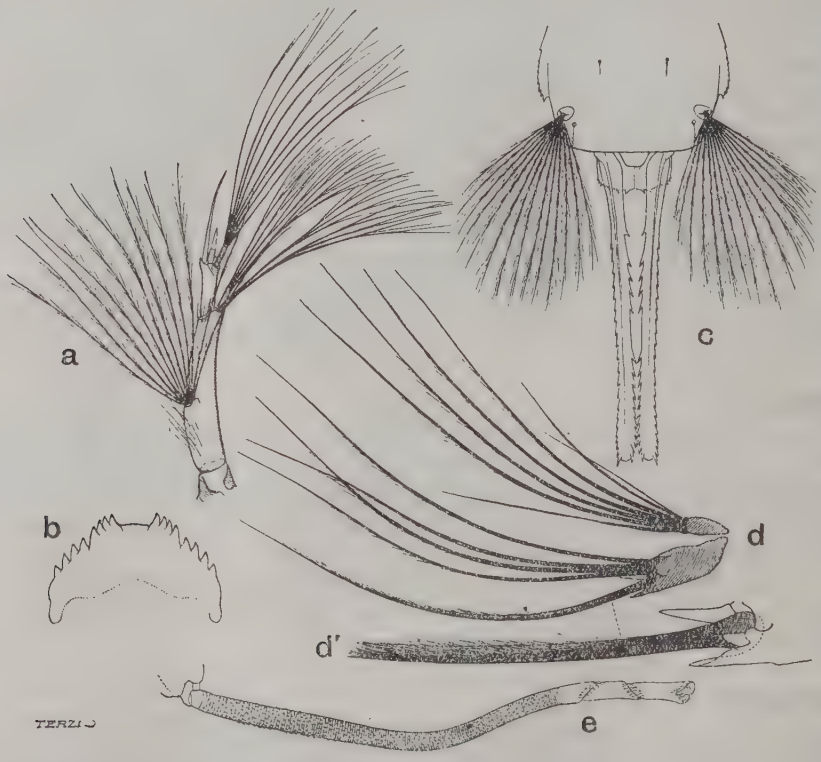

Fig. 6. *Ficalbia fusca*, Leic.: *a*, antenna of larva; *b*, mentum of larva; *c*, end of abdomen of pupa; *d*, metathoracic plates of larva, with attached tufts; d^1, base of stout bristle of larger metathoracic plate further enlarged; *e*, respiratory horn of pupa.

each branch again dividing several times. One of the apical bristles is also large and divides into about five branches at some distance from base, the other is short; papilla small. Mentum very small and of peculiar form: instead of a median tooth there is a straight edge in the centre on each side of which project a row of four equal teeth, outside these being four other teeth more widely spaced. *Thorax* with the lateral tufts rather large, and arising from distinct chitinous plates, that of the upper metathoracic tuft large and bearing a distinct spine; the lower tufts of both meso- and metathorax comprise one long stout single bristle and a 4–6 branched tuft, the stout

bristle being hairy, weak on one side and curled up in slide preparations. *Abdomen* with large plumose lateral tufts on segments 1 and 2, those on 3–7 smaller, but each with about 4 branches; dorsal tufts well-developed. Segment 8 with three lateral branched tufts, the uppermost of which is the largest. Comb a patch of about 30 simple sharp spines, those towards the base very small, the others larger; no plate. *Anal segment* rather short, with a complete chitinous ring, which is finely hairy on and towards the posterior margin. Outer dorsal hair 3-branched, the inner with 6–8 branches. Lateral hair long and strong, single or occasionally double. Brush consisting of 4–6 hairs, each 2 to 3 branched; no distinct cross bars. *Siphon* rather pale, slightly tapering and slightly curved forwards at tip; index about 6. Acus small. No pecten. Tuft moderately long, with 2–3 hairs, placed at about one-third. Valves rather small, normal.

Habitat.—Rot-hole in forest tree at ground-level, associated with *Heitzmannia funerea*; the water was muddy, apparently from storm water.

In the revision of the Oriental Culicines (Edwards, Ind. Journ, Med. Res. x, p. 455, 1922) *Ingramia* was placed as a subgenus of *Ficalbia*, but it was pointed out that the Oriental *Dasymyia fusca*, Leic. (previously referred to *Ingramia*) differed from the African species in the structure of the female antennae. From the above description of the larvae and pupae it is clear that there is no close relation between this species and the African *Ingramia malfeyti* (Newst.); the latter, for example, has normal antennal bristles and a basally situated siphon-tuft; its pupa (which has not been described) has normal respiratory horns and paddles. From the evidence of the early stages it would seem that *Ingramia* should be kept separate from *Ficalbia*. On the other hand the resemblances between *F. fusca*, *F. mediolineata* and *F. luzonensis*, are so great that these three are clearly congeneric. Whether the genotype of *Ficalbia* (*F. minima*, Theo.) belongs strictly to the same group remains to be proved. *F. fusca* shows several points in common with *Mimomyia*, for example, the large spine-bearing plate of the lower metathoracic tuft, and the long respiratory horns of the pupa.

Culex (Lophoceratomyia) fraudatrix, Theo. (fig. 7).

Larva.—*Head* large, considerably broader than long, mainly pale in colour, but with several dark spots on posterior part of clypeus, and also darkened round occiput. Clypeal spines moderately stout and straight. Tuft *A* large, plumose, with 7–12 branches; *B* and *C* both double, very long and reaching far beyond front of head; *C* placed obliquely behind *B*; *d* trifid, rather longer than usual. *Antennae* fully as long as the head, rather strongly curved; a dark ring at the base and another immediately beyond the tuft, leaving the tip pale; shaft with strong spicules except on the slender terminal portion. Tuft very large, with 25–30 plumose branches, placed beyond two-thirds. Preapical bristles placed a short distance before the tip, both very long, about two-thirds as long as the shaft of the antenna; one of the terminal bristles also long, but shorter than the preapical pair. *Mentum* with a moderately large median tooth and 10–12 small teeth on each side, the outer one or two sometimes a little larger and more detached, but not conspicuously so. *Thorax* with the lateral tufts large, plumose, and set in small but distinct chitinous plates. Prothoracic hairs very long, extending forwards far beyond front of head. *Abdomen* with smooth skin; the lateral tufts mostly triple. Eighth segment with three rather large branched tufts; the upper pair 6-branched and plumose; the middle (subsiphonal) pair with 6–8 branches and very thickly plumose, the ends of the branches sometimes split into several twigs. Comb a patch of about 30 very small dark scales, not obviously fringed. *Anal segment* with the chitinous ring hardly longer than broad, almost smooth on the posterior margin; inner dorsal hair with two small branches from base; lateral hair small, with 3–4 branches. Brush with about 10–12 large many-branched tufts. *Siphon* long, brown, usually with a dark brown ring in the

middle ; index about 8–9 ; in shape slightly tapering on about the basal half, then almost parallel-sided, the tip very slightly widened. Three or four pairs of ventral or ventro-lateral tufts, which have usually 2–3 branches, the branches simple and hardly longer than the diameter of the siphon. Pecten of 10–12 rather slender teeth, which are fringed along one side with fine denticles, those at the base rather stronger, the last tooth at about one-third the length of the siphon.

Habitat.—Pot-holes, etc., chiefly in mangrove tidal area, but also away from coast.

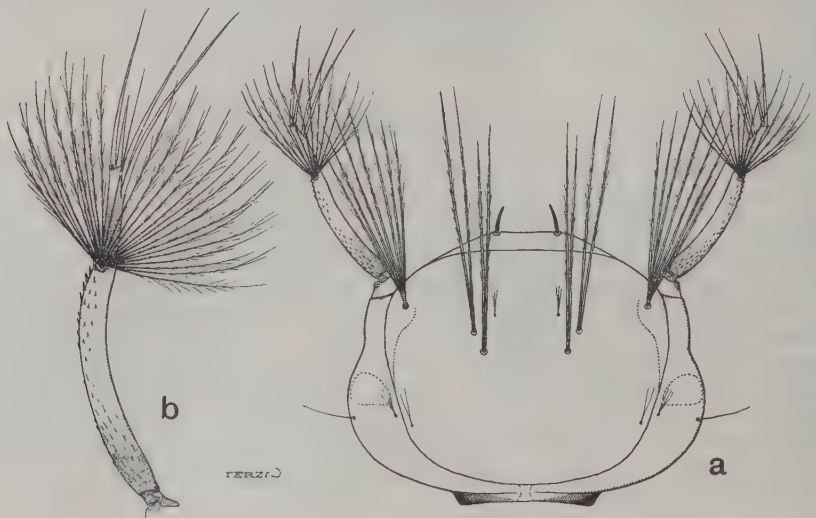

Fig. 7. Larva of *Culex* (*Lophoceratomyia*) *fraudatrix*, Theo. : *a* head from above (mouth-brushes omitted) ; *b*, antenna.

Culex (Lophoceratomyia) quadripalpis, Edw. (*sylvestris*, Leic.).

Larva.—Very similar to *C. fraudatrix*, differing chiefly as follows :—Shaft of antenna beyond the tuft entirely dark ; the longer apical bristle only about half as long as the pre-apical bristles. Tuft *A* less plumose, with 6–8 branches. *C* placed almost directly behind *B* or only slightly nearer mid line of head. Siphon shorter, index about 6·5, the tufts rather longer and more distinct.

Habitat.—With *C. fraudatrix*.

Culex (Lophoceratomyia) minor, Leic.

Larva.—Structurally similar to *C. fraudatrix*, differing chiefly as follows :—Antennae without dark ring at base, the narrow apical portion slightly and uniformly darkened ; the longer apical bristle almost or quite as long as the pre-apical. Clypeal tuft *A* about 8 branches. Siphon uniformly pale brownish and rather longer ; index about 9–10 ; the basal third tapering, the outer two-thirds parallel-sided and very slender. Pecten with about 16 teeth, similar in form to those of *C. fraudatrix*, but the basal denticles somewhat stronger. Gills rather pointed, over twice as long as the anal plate.

Habitat.—The Singapore specimens were found in rock-pools in company with *Aëdes* (*Finlaya*) *saxicola*, Edw. Other specimens in the British Museum were taken in old fallen bamboos at Ulu Gombak, F.M.S., by Dr. H. P. Hacker ; these differ

from the rock-pool specimens only in the darker siphon and stronger basal denticles to the pecten teeth ; the adults are quite similar. Barraud records the larvae from bamboos, rock-pools and tree-holes.

Culex (Lophoceratomyia) ? cinctellus, Edw. (fig. 8, *a*, *b*).

Larva.—*Head* broader than long, but not so large as in *C. fraudatrix*, pale in colour. Clypeal spines slender, bristle-like, curved. Clypeal tufts *A*, *B* and *C* each with about eight slightly plumose branches, *C* very obliquely behind the *B*, and neither of them reaching appreciably beyond the front of the head. *Antennae* entirely pale, moderately slender and scarcely curved, not more than two-thirds as long as the head ; shaft with numerous small spicules. Tuft placed at three-fifths, composed of about 12 slightly plumose branches which do not reach beyond tip of shaft. Subapical hairs slender, pale, placed very close to the tip and not more than half as long as the shaft. *Mentum* with a rather small median tooth, and about ten teeth on each side of this, two or three on each side being larger and more detached. *Thorax* with the lateral tufts large ; prothoracic hairs only just reaching front of head, the innermost hair double. *Abdomen* much as in *C. fraudatrix* ; subsiphonal tuft less heavily plumose ; comb-teeth pale. *Anal segment* with the posterior margin of the plate finely spinose (about 10–12 short spines). Inner dorsal hair simple. Brush composed of 6–8 small tufts which have at most 4 or 5 branches, the transverse bars not well developed. Gills thick, rather blunt-ended, twice as long as the plate. *Siphon* brownish ; slightly tapering on basal half, then almost parallel-sided ; index about 6–6·5. Four pairs of small latero-ventral tufts which are mostly two-branched, the branches simple and about as long as the diameter of the siphon. Pecten of about ten teeth, which are rather short, with a row of five or six denticles on one side, several of these being as long as the main tooth.

The adults issuing from these larvae were unfortunately lost, and their identity is therefore uncertain ; from naked-eye appearance they seemed to be *Lophoceratomyia* with banded abdomen, and were therefore regarded as *C. cinctellus*.

Culex (Lophoceratomyia) navalis, Edw. (fig. 8, *e*, *f*, *g*, *h*).

Larva.—General colour creamy yellow in life, not blue. *Head* large, considerably broader than long, pale in colour. Clypeal spines strong, straight and blackish. Hairs *A*, *B* and *C* plumose and moderately long ; *A* with 4–5 branches, *B* and *C* both single, *C* placed close to, and obliquely behind *B*. Antennae pale, about as long as the head, shaft moderately stout and with numerous spicules, the part beyond the tuft much more slender and smooth ; tuft placed beyond two-thirds, with 12–15 sub-plumose branches, not very long ; bristles all terminal, three of them very long (fully half as long as the antenna) and rather stout. Mentum rather large, black, parallel-sided at the base, the end part pointed ; median tooth large, with about 5 small teeth on each side, and then one large tooth ; one or two smaller teeth on sides towards base. *Thorax* very stout with the two inner pairs of prothoracic tufts each with 3–4 branches, the tufts, however, rather short, not nearly reaching front of head ; larger tufts of meso- and metathorax with 5–8 branches. *Abdomen* with smooth skin as in most allied species. Lateral tufts of first two segments with 4–6 branches, the other lateral hairs double. Comb a patch of 30–40 slender, needle-like scales. Subsiphonal tuft large, plumose, with 6–8 branches. *Anal segment* not much longer than deep ; outer and inner dorsal hairs both simple ; lateral hair small and simple. Gills pointed, over twice as long as the plate. *Siphon* pale in colour, rather strongly and evenly tapering from the base ; index about 5. Eight pairs of sub-plumose ventral hair-tufts, the first of which is placed at about one-third or one-fourth the length,

and the last almost on the extreme tip ; the longest tufts are not much shorter than the siphon itself and have 4–6 branches. Pecten of 7–9 long pointed teeth which have a row of long fine denticles along one side, basal denticles not stronger than the others ; the last tooth close to the base of the first tuft, rarely beyond it.

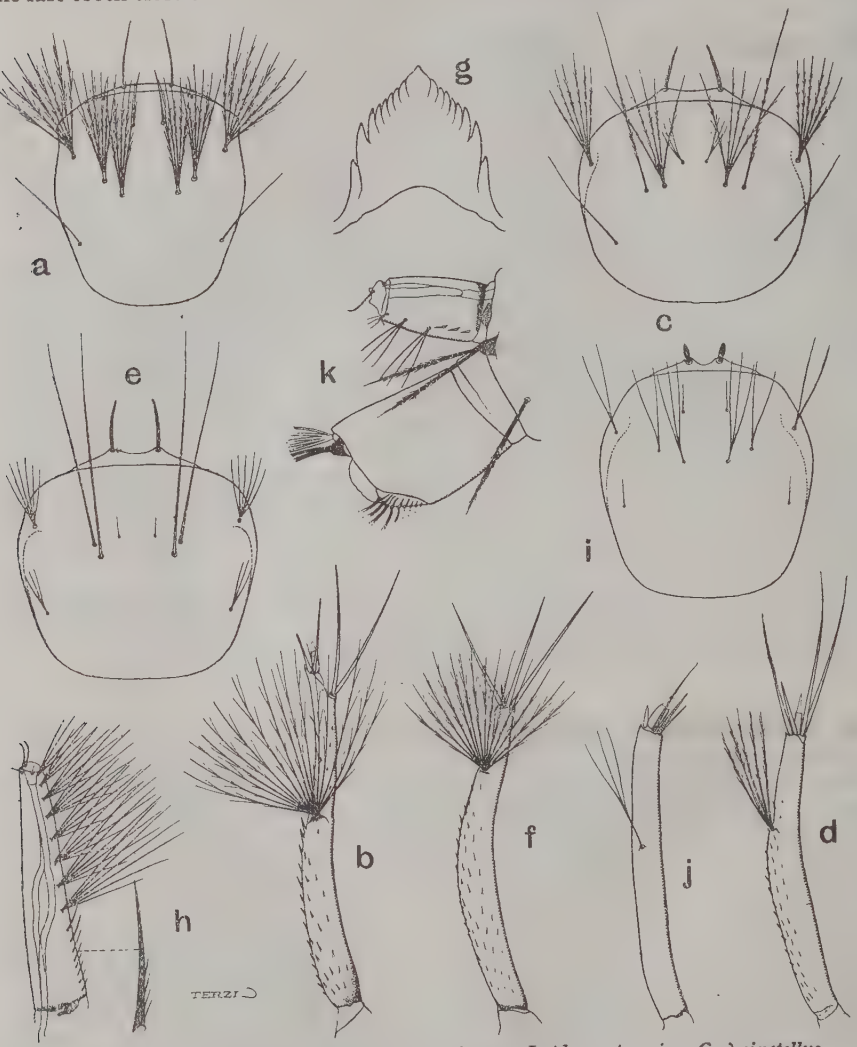

Fig. 8. Details of larvae of *Culex*, subgenus *Lophoceratomyia*. *C. ? cinctellus*, Edw. : *a*, clypeus ; *b*, antenna. *C. hewitti*, Edw. : *c*, clypeus ; *d*, antenna. *C. navalis*, Edw. : *e*, clypeus ; *f*, antenna ; *g*, mentum ; *h*, siphon (with enlarged pecten-tooth). *C. curtipalpis*, Edw. : *i*, clypeus ; *j*, antenna ; *k*, siphon and anal segment.

Habitat.—Pitcher-plants.

These specimens seem to agree with the larva *B* mentioned in the original description of this species.

Culex (Lophoceratomyia) coerulescens, Edw.

Larva.—Structually very similar to *C. navalis*, but the body in life (especially the thorax) has a strong blue tinge, and the appendages are much more highly chitinised, the antennae and siphon being entirely black. The antennae are straighter, and their bristles stronger; the clypeal hair *C* is double.

Habitat.—Pitcher-plants.

Culex (Lophoceratomyia) hewitti, Edw. (fig. 8, *c*, *d*).

Larva.—Similar to that of *L. navalis*, described above, differing chiefly as follows: Body, including head and siphon, very pale. Head smaller. Antennae rather shorter, the tuft placed at three-fifths and the spicules on the shaft much less conspicuous. Mentum smaller, rather differently shaped, the two outer teeth on each side larger. Hairs *B* and *C* placed side by side, *B* single, *C* with 6–8 branches. Thorax not so stout. Innermost prothoracic hair with 2–3 branches, the adjoining hair single or double. Gills longer, fully three times as long as the anal plate. Siphon longer, index 7–9; seven pairs of ventral hair-tufts, the last placed well before the tip.

Habitat.—Pitcher-plants.

This is evidently the larva *A* referred to under the original description of *C. navalis* (Bull. Ent. Res., xvii, p. 121, 1926).

Culex (Lophoceratomyia) eminentia, Leic., var. (fig. 9).

Larva.—*Head* rounded, pale in colour, Clypeal spines slender, bristle-like, moderately long; the front margin of the clypeus not emarginate between the spines

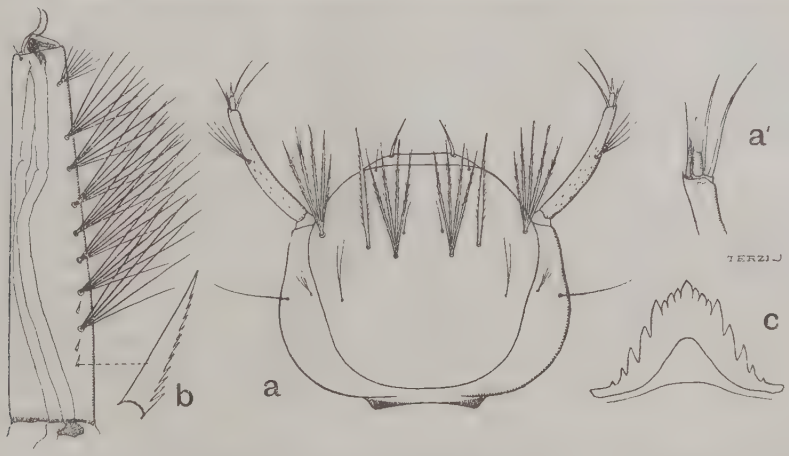

Fig. 9. Larva of *Culex* (*Lophoceratomyia*) *eminentia*, Leic.: *a*, head from above; *a'*, tip of antenna further enlarged; *b*, siphon, with enlarged pecten-tooth; *c*, mentum.

Hairs *A*, *B* and *C* plumose and moderately long, but not reaching much beyond front of head; *A* with 5–6 branches, *B* single and unusually stout (rarely double), *C* 4-branched. Antenna a little over half as long as head, pale, with the tip slightly darkened; shaft appearing smooth under low power, a few fine spicules visible under high power; tuft small, 4-branched, placed at about two-thirds, the part of the shaft beyond it somewhat narrowed; bristles all apical, three long and hair-like, one

shorter; papilla small and pale. Mentum large, black, triangular; median tooth rather small, with three slightly smaller teeth on each side of it; outside these on each side are three very large and more widely spaced teeth, then one more smaller one. *Thorax* with the lateral tufts rather large, some with as many as six branches; innermost and outermost prothoracic hairs double. *Abdomen* with the lateral tufts on segments 1 and 2 with 3–4 branches, on segments 3 and 4 with 3 branches, on 5 and 6 double. Eighth segment with the subsiphonal tuft large, 7-branched; below it a longish single hair, and below that a double hair. Comb a patch of about 25 long, slender, finely fringed teeth. *Anal segment* long, completely ringed as usual. Outer dorsal hair single, the inner with one small branch at the base. Brush with about 12 tufts, some of which have as many as 8–10 branches. Gills long, slender, about twice as long as the plate. *Siphon* pale in colour, slightly and evenly tapering, index about 5. Acus large. Seven or eight pairs of ventral tufts, the longest over half as long as the siphon, the last pair very small and placed a short distance from the tip; each tuft with 4–6 branches. Pecten of from one to three teeth, rather short and finely denticulate on one side; the last tooth usually placed between the first two tufts. Valves with a rather long curved bristle. Tracheae slender.

Habitat.—Pitcher-plants.

This larva has much in common with that of *C. jenseni* as figured by de Meijere, the chief difference being that the siphon is longer, with 7–8 instead of 4–5 pairs of tufts, and the pecten-teeth fewer.

Culex (Lophoceratomyia) jenseni, (de Meij.).

A few larvae were obtained at Singapore which agree rather well with de Meijere's description and figures of *C. jenseni*; only one male was reared, and this also, as far as can be seen (it is unfortunately much damaged) agrees with de Meijere's specimens.

Larva.—The Singapore larvae show the following characters: No blue colour in body. *Head* scarcely broader than long, pale in colour. Clypeal spines rather long, stout, straight and black, the front margin of the clypeus scarcely emarginate between them. Hairs *A*, *B* and *C* plumose, projecting slightly beyond front of head, with 6–7, 2, and 2–3 branches respectively; *C* placed rather obliquely behind *B*, instead of almost directly inside as in *C. curtipalpis*. Antennae about two-thirds as long as the head, stout, the shaft almost perfectly smooth, a very few fine spicules being visible under high power; tuft small, 4-branched, placed at two-thirds, the part of the shaft beyond it only slightly narrowed; bristles all apical, three of them long, stout, almost spine-like. Mentum with a very large central tooth, on each side of which are first about six smaller teeth, and then three or four others, larger and more widely spaced (the shape of the mentum in the specimens before me differs slightly from de Meijere's figure, but the tooth-formation is similar) *Thorax* with the lateral tufts plumose, the larger tufts with 6–9 branches; innermost prothoracic hair double, the rest single. *Abdomen* with the lower lateral tuft of the first segment 4-branched, the other lateral tufts mostly double. Comb consisting of two irregular rows of long slender teeth, fringed round the pointed tip. Sub-siphonal tuft of eighth segment large, plumose, with 7–9 branches; sub-ventral hair double. *Anal segment* with about 10 tufts in the brush, each with 6–8 branches. Lateral hair small and double. Gills about twice as long as the plate. Inner and outer dorsal hairs single. *Siphon* pale, very little tapering, index 3–3·5. Five or six (de Meijere says four) pairs of plumose 5–6-branched ventral tufts, the largest tufts about half as long as siphon, also a small sub-apical pair of 4-branched tufts, the branches of which are not or scarcely plumose. Pecten of 2–5 teeth, the last tooth usually between the first two tufts.

Habitat.—Pitcher-plants.

Culex (Lophoceratomyia) curtipalpis, (fig. 8, *i*, *j*, *k*).

Larva.—General colour blue, as in *C. coerulescens*. *Head* scarcely broader than long, pale in colour. Hairs *A*, *B* and *C* rather short, not reaching front of head, each with 3-4 plumose branches, and arranged as usual in *Culex* in a nearly straight line. Clypeal spines very short and thick, the front margin of the clypeus between the spines rather deeply excavated. Antennae about half as long as the head, pale in colour, shaft smooth and almost cylindrical, rather slender; tuft small with 3–4 hairs, placed a little beyond the middle; bristles all apical, one of the four shorter and blunter than the others; papilla large and chitinised. Mentum black, of normal shape; about 7–8 teeth on each side of the median tooth, the last three or four on each side rather larger and wider apart. *Thorax* with the anterior prothoracic hairs all single; lateral tufts of meso- and meta-thorax mostly double. Abdomen with the lateral tufts on segments 1 and 2 double, on 3 and 4 triple, on 5–7 double. Eighth segment with the subsiphonal hair double, the branches plumose and stout; subventral hair single, stout and plumose; the other hairs very minute, single and simple. Comb an irregular row of about six pale, blunt, finely-fringed teeth. *Anal segment* ringed as usual. Outer dorsal hair simple as usual, the inner with 4–5 equal branches. Lateral hair very small, with 3–5 branches. About 12 tufts in the brush, each with 2–5 branches. Gills not much longer than the saddle. *Siphon* pale yellow, remarkably short, index barely 1·5. Acus large and broad. Three (rarely four) pairs of ventral hair tufts, of which the first two (or three) have 4–5 slightly plumose branches, and the third, which is smaller and placed at the extreme tip of the siphon, has about 5 simple branches. Pecten composed of 2–4 sharp and almost simple teeth. Valves normal, but one pair with a strong curved bristle. Tracheae very slender and delicate, but the chitinous internal rod strong, dark, and reaching to base of siphon or nearly,

Pupa.—Respiratory horns very short, of the normal form. Dendritic tuft on first abdominal segment well developed. Segments 3–6 each with one single rather long sublateral hair, that on segment 4 much the longest; remaining hairs on these segments very small. Lateral hairs of segments 7 and 8 three-branched, plumose, the tuft of segment 8 nearly half as long as the paddle, its branches more or less split apically. Paddles rather small, rounded, slightly emarginate apically, without fringe, terminal hair minute.

Habitat.—Pitcher-plants.

This larva shows a number of interesting features, notably in the form of the antennae and the extreme shortness of the siphon. In general appearance it is more like an *Aëdes* than a *Culex*, but we believe that there has been no mistake in association of larva and adult, and the presence of three pairs of siphonal tufts confirms the location of the species in *Culex*. It was less commonly met with than most of the other pitcher-plant species.

The larva has a peculiar method of locomotion, using its short siphon as a foot.

HOST SELECTION IN *PYRAUSTA NUBILALIS*, HÜBN.

By W. R. Thompson, Ph.D., D.Sc., and H. L. Parker, D.Sc.

During the last few years a number of papers have been published by entomologists in connection with the hypothesis known as the " Hopkins host-selection principle." This principle, as defined by Dr. A. D. Hopkins himself, is that an insect species that breeds in two or more hosts will continue to breed in the host to which it has become adapted. Thus, according to this author, the mountain pine beetle, *Dendroctonus monticola*, will destroy mountain pine, yellow pine, lodgepole pine and sugar pine, but if it becomes established in one species of pine through many generations, the beetles on emergence show a decided preference for the species in which they have bred and will not, in fact, attack any other.* In 1922 Craighead† published a paper giving the results of experiments carried on during a number of years with about a dozen species of Cerambycids. He states that in practically all the species studied the adults show a marked predilection for the host in which they have fed as larvae, provided that they are not deterred by other factors. Continued breeding in a given host is said to intensify the preference for that host. With some beetles whose larvae can be transferred to another species of plant and successfully reared therein, this association with the new host for a year, or even less, during the latter part of the larval life is said to determine a preference for this in the resulting adults. The author believes that his experiments may indicate the mode of origin of certain closely related species or varieties. The conclusions at which he has independently arrived were long ago suggested by Walsh§. That new forms do not thus arise more rapidly in Nature, Craighead considers to be due to the high mortality of the young larvae in the new hosts.

In 1927 A. O. Larsen‡ published a paper on the host-selection principle as applied to *Bruchus quadrimaculatus*, Fabr. In this paper, in which are summarised a number of contributions by previous authors bearing more or less directly on the question, Larsen gives in detail the results of some very careful and extensive experiments with the southern cowpea weevil. He concludes that the adults of this species show no marked predilection for the host in which they have bred and that continued breeding in a given host does not appear to intensify the preference for the host.

The experiment performed by Larsen, together with the results obtained by other workers from whose papers he quotes, show clearly that the choice of hosts is certainly not always in accordance with the Hopkins host-selection principle. On the other hand the data presented by Craighead and others in support of the hypothesis are certainly of exceptional interest, not only because of their value in certain practical operations, but also from a general biological standpoint. According to these experiments, the choice of hosts by the adult depends not so much upon its inherited constitution as upon the conditions to which it has been exposed during its ontogeny, any inherited preferences being annihilated—in some cases at least—by the transfer of a larva to a new host even during the course of its life-history. This might be explained by supposing that the choice of hosts is a purely " somatic " character ; but as the authors assert that the preference for a given host is intensified by breeding in the same host during a series of generations, it is necessary to admit the influence of external conditions upon the germ cells. These data are thus of great interest in that they afford support for the hypothesis of the inheritance of acquired characters.

But as is well known, the hypothesis of the inheritance of acquired characters is by no means generally admitted by biologists. Ever since Weismann's penetrating

* Rev. Appl. Ent., v, p. 120.
† Jl. Agr. Res., xxii, pp. 189–220.
§ 1864–65. Proc. Ent. Soc. Philadelphia, iii, pp. 403–430, iv, pp. 194–216.
‡ Ann. Ent. Soc. America, xx, no. 1, pp. 37–78.

criticism, this hypothesis, in spite of its attractiveness—for it is probably the only intelligible theory of a natural evolutionary process ever advanced—has been in very doubtful standing, though many workers have made repeated efforts to produce evidence in its favour. In a recent essay, the distinguished French biologist L. Cuénot,* after a keen critical examination of the evidence of the inheritance of acquired characters writes as follows: "Nous conclurons donc cette étude par une négation complète et absolue de l'inscription patrimoniale des caractères acquis d'abord par le soma, que ce soient des mutilations, des effets mecaniques ou chimiques, des actions de climat, de dressage, d'usage ou de non-usage." The reason for this drastic judgement is of course that none of the evidence hitherto put forward has been able to stand the test of careful analysis. In view of this fact, the data published in favour of the Hopkins host-selection principle must be received with caution and interpreted with care. The experiments performed by Craighead, Pictet, Schroder and others, are undoubtedly extremely interesting and suggestive and might well carry conviction if the thesis in support of which they have been made were less open to controversy; but as a demonstration of the inheritance of acquired characters, they will hardly be considered sufficient by most biologists. It is therefore very desirable that they should be repeated on a larger scale over a longer period and extended to groups other than those studied.

With this object in mind we carried out at Hyères, France, in the summer of 1927, an experiment on host-selection in the European corn borer (*Pyrausta nubilalis*, Hübn.). This insect, which is widely distributed throughout Europe, was accidentally introduced into North America some years ago, and has now spread over a considerable area in the North-Eastern United States and Canada. It attacks a large number of plants both in Europe and America. Over 200 hosts are recorded for the species in the United States and Canada by Caffrey & Worthley.† Although the insect is very polyphagous, in Europe it is chiefly found in maize in regions where climatic conditions permit of the successful cultivation of that crop; while in the areas north of the maize belt, at least in Western Europe, it chiefly attacks weeds, its favourite host being *Artemisia vulgaris*, L., sometimes called the Common Mugwort. In some regions *Pyrausta nubilalis* is found breeding in both maize and *Artemisia*, but in others it attacks only one of these two hosts, being of course occasionally found also in other plants. Thus in the region around Paris, it lives principally in *Artemisia vulgaris*, and though it is found at times in other weeds it has no opportunity to attack maize, which is not grown in this district. On the other hand, in the Department of the Gers, in South-western France, practically the only food-plant of *Pyrausta nubilalis* is maize, though very slight infestations are occasionally observed in broom corn in the Department of the Lot et Garonne, north of the Gers. In this latter region *Artemisia vulgaris* is uncommon, and in such specimens as we have collected along the railway lines and elsewhere, no *Pyrausta* larvae have ever been found. As conditions in the Parisian and South-western regions have been relatively stable for a long period of time, it seems fair to assume that we have here two strains of *Pyrausta nubilalis* that have been practically confined for many generations to two different host-plants, the one living in *Zea mays*, the other in *Artemisia vulgaris*. The opportunity for an admixture between the two strains is practically negligible, as their habitats are separated by a rather broad belt in which neither maize nor *Artemisia* is abundant.

Therefore, if continuous breeding in a given host-plant really induces a preference for it and a dislike for and rejection of other hosts, these preferences and dislikes ought to be manifest in the two strains of *Pyrausta nubilalis* just mentioned, which thus constitute peculiarly suitable material for the study of the Hopkins host-selection principle.

* "Le Transformisme," by L. Cuénot, R. Dalbiez, E. Gagnebin, W. R. Thompson and L. Vialleton, Paris, Vrin, 1927.

† U.S. Dept. Agr., Bur. Entomology, Bull. no. 1476.

The experiment based on this idea was conducted, as already stated, at Hyères, in Southern France, during the months of May, June and July, 1927, with moths reared in the out-door insectary from the larvae collected in maize in the Department of the Gers in South-western France and in *Artemisia vulgaris* in the waste ground around Paris. The adults were placed on emergence in two wire screen cages measuring 85 cm. in height by 35 cm. in breadth and 60 cm. in length, placed side by side on a table standing on a terrace behind the Laboratory in a spot well shaded in the early morning but exposed to the sun during the rest of the day. In each cage were placed two large flower pots, the one containing several growing maize plants, the other a growing plant of *Artemisia*, presenting as nearly as we could judge, approximately the same amount of leaf surface as the maize. An examination of the plants, pots and wood-work of the cage was made on an average about every three days, when all egg-masses were removed and counted. The relative positions of the maize and *Artemisia* were changed at each examination in order to compensate for any difference in exposure to light of the two ends of the cage. The plants were watered and the moths fed with honey-water daily. As the adults died off or escaped, they were replaced by freshly emerged individuals, though it was not found possible to keep the populations of the two cages constant in number.

The experiment on the *Artemisia* strain of *Pyrausta nubilalis* was started on 11th June 1927, when 12 males and 12 females were placed in a cage with a pot of *Artemisia* and a pot of maize. During the period from 11th to 20th June the maize plants were about twice as high as the *Artemisia*, during the remainder of the experiment the maize was kept cut down to the same height as the *Artemisia*. This was done because it was thought that the higher plants might receive more egg-masses than the lower, in spite of their other characteristics, since the moths were observed to congregate in the upper part of the cages.

The results of this experiment are summarised in the following table :—

Date.	Total egg-masses found.	Total eggs found.	On maize.		On *Artemisia*.		On woodwork, etc.	
			Masses.	Eggs.	Masses.	Eggs.	Masses.	Eggs.
14.vi	14	275	12	236	2	39	0	0
16.vi	16	224	14	202	2	22	0	0
18.vi	15	194	15	194	0	0	0	0
20.vi	21	285	21	285	0	0	0	0
22.vi	105	2,092	37	698	62	1,280	6	114
27.vi	22	364	16	277	5	47	1	40
30.vi	11	264	3	58	8	206	0	0
4.vii	9	165	5	97	4	68	0	0
9.vii	17	418	10	262	7	156	0	0
15.vii	30	545	19	373	11	172	0	0
Totals	260	4,826	152	2,682	101	1,990	7	154

During the period when the maize was twice the height of the *Artemisia*, the totals were as follow :—

Total egg-masses found.	Total eggs found.	On maize.		On *Artemisia*.		On woodwork, etc.	
		Masses.	Eggs.	Masses.	Eggs.	Masses.	Eggs.
66	978	62	917	4	61	0	0

During the period when the maize and *Artemisia* were the same height, they were as follows :—

Total egg-masses found.	Total eggs found.	On maize.		On *Artemisia*.		On woodwork etc.	
		Masses.	Eggs.	Masses.	Eggs.	Masses.	Eggs.
194	3,848	90	1,765	97	1,929	7	154

Reduced to percentages, the distribution of the eggs in this experiment was thus as follows :—

	Maize.		*Artemisia*.		Woodwork, etc.	
	Masses.	Eggs.	Masses.	Eggs.	Masses.	Eggs.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
First period	94·0	94·0	6·0	6·0	0·0	0·0
Second period	46·3	45·8	50·0	50·0	3·7	4·2
Total period	58·4	55·6	38·8	41·2	2·8	3·2

As is fairly evident, the results obtained by the counts of eggs and egg-masses are practically identical.

During the latter part of the experiment, when the maize and *Artemisia* plants were at the same height, the number of egg-masses deposited upon these two host-plants was approximately the same. The actual figures are slightly in favour of *Artemisia*, but the difference is too small to be convincing, especially when one considers that the amputation of the tip of the plant may diminish its attractiveness ; for recent experiments seem to show that the different parts of the plants differ in this respect.

Again, during the period when the maize plants were higher than the *Artemisia*, the great majority of the eggs (94·0 per cent.) were deposited upon it, in spite of the fact that the females utilised in the experiment were of an *Artemisia*-inhabiting strain.

The results of this experiment, considered independently, would seem to indicate that the *Artemisia*-infesting habit of the moths of this strain, whose ancestors have probably developed at least for many generations in this food-plant, has not produced any very strong preference for it. The attraction of *Artemisia* for the females was barely predominant even when conditions were markedly favourable to this host-plant ; when conditions were favourable to maize, the *Artemisia* was almost completely neglected. As the maize utilised in the experiment was not such as one expects to find infested, except to a very mild degree, under field conditions, it may fairly be said that the original host was to some extent abandoned for a new one, even though the condition of the new one was in general inferior or at least not better than that of the original.

* * * * *

The experiment on the strain of *Pyrausta nubilalis* from maize was set up on 20th May 1927 and conducted in the same way as the one just described. The plants

were kept at the same height throughout. The examinations for eggs gave the following results :—

Date.	Total egg-masses found.	Total eggs found.	On maize.		On *Artemisia*.		On woodwork, etc.	
			Masses.	Eggs.	Masses.	Eggs.	Masses.	Eggs.
23.v	4	43	3	30	1	13	0	0
24.v	3	74	0	0	2	47	1	27
28.v	9	226	0	0	2	62	7	164
30.v	15	324	4	94	1	18	10	212
1.vi	23	422	15	278	0	0	8	144
4.vi	37	716	26	524	2	25	9	167
10.vi	14	345	12	315	1	15	1	15
13.vi	38	761	36	711	2	50	0	0
15.vi	5	124	4	108	1	16	0	0
20.vi	11	230	8	152	3	78	0	0
22.vi	27	441	20	331	7	110	0	0
27.vi	3	56	1	50	2	6	0	0
30.vi	9	178	0	0	3	47	6	131
4.vii	3	57	2	38	1	19	0	0
9.vii	2	18	0	0	2	18	0	0
15.vii	41	686	39	670	2	16	0	0
Totals	244	4,701	170	3,301	32	540	42	860

Reduced to percentages, these results are as follow :—

Maize.		*Artemisia*.		Woodwork, etc.	
Masses.	Eggs.	Masses.	Eggs.	Masses.	Eggs.
Per cent. 69·6	Per cent. 70·1	Per cent. 13·2	Per cent. 11·5	Per cent. 17·2	Per cent. 18·4

As in the previous experiment, the results obtained by the count of eggs are not noticeably different from those obtained by the count of masses. The great majority of eggs was deposited on the maize plants, the proportion placed on *Artemisia* being actually less than that placed on the flower pots, the woodwork of the cage, and the leaves of some miscellaneous plants which had grown up in the pots.*

The results of these two experiments may be summarised as follows :—

Of the egg-masses deposited by the moths of *P. nubilalis* from *Artemisia*, 38·8 per cent. were deposited upon this host-plant and 61·2 per cent. elsewhere, while of the egg-masses deposited by the *P. nubilalis* females from maize, 69·6 per cent. were deposited upon maize and 30·4 per cent. elsewhere. The females from *Artemisia* deposited 58·4 per cent. of their egg-masses upon maize during the whole period of the experiment, but only 46·3 per cent. on this plant during the period when maize and *Artemisia* were kept at the same height.

Thus, in spite of the long association with this plant, which may indeed be the original host of the species, the *Pyrausta nubilalis* from *Artemisia* exhibited no striking preference for this food-plant, but deposited the majority of their eggs on maize, exhibiting only a slight and hardly significant preference for *Artemisia* even when conditions in the experiment were distinctly favourable to this host. The two experiments taken together indicate clearly that of the two plants employed maize is the favoured host of both the *Artemisia* and maize strains of *Pyrausta nubilalis*.

* These were Pigweed (*Amaranthus* sp.) on which 5 masses with 110 eggs were deposited and Lamb's Quarters (*Chenopodium album*, L.) on which 1 mass of 20 eggs was deposited.

It must, however, be noted that the proportion of egg-masses deposited upon maize by the *Artemisia* strain was 14·0 per cent. lower than by the strain from maize; and that in the former, 38·8 per cent. of the masses not deposited on maize were placed on *Artemisia* and only 2·8 per cent. on the woodwork of the cage and pots, while in the maize strain, of the eggs not deposited upon maize fewer were placed on *Artemisia* than on the pots, woodwork and adventitious plants. These results seem to indicate that the *Artemisia* exerted a positive attraction on the individuals obtained from that plant, whereas to those obtained from maize it signified nothing, considered as a host-plant, receiving eggs just as did the woodwork, probably because the females happened to be resting upon it at moments when they felt a desire to oviposit. The development of these individuals (or of this strain) in *Artemisia*, though it had not prevented them from being attracted by maize, thus seems to be correlated with a less strongly marked taste for this plant. To this extent the results of our experiments are in agreement with the Hopkins host-selection principle.

It does not follow, however, that these results, even if confirmed by further experiment, afford support for the hypothesis of the inheritance of acquired characters. Such differences in the preferences of the females of the two strains as we have noted are not necessarily inherited but may be merely somatic characters, since the adults used are not merely the offspring of *Artemisia* and maize inhabiting parents but individuals which have themselves developed in the host-plants mentioned. The facts are perfectly explicable on the hypothesis that *Pyrausta nubilalis* is a species having a strong innate preference for maize, which can be increased by the development of the individual in that host or decreased by development in another, for which a less strongly marked and probably non-inherited preference is then produced. This hypothesis would correspond in a general way with the statement made by Craighead to the effect that when a larva passes the latter part of its existence in a given host the adult often tends to select this host in preference to others.

Craighead asserts further, however, that the preference for the host habitually attacked actually increased from generation to generation. Such a cumulative process, as we have already pointed out, is of course explicable only on the hypothesis of the inheritance of acquired characters. If such a process occurred in *Pyrausta nubilalis* we should scarcely expect the *Artemisia*-inhabiting strain to exhibit any liking for maize. The strong attraction exerted upon it by this host appears to us to indicate that host-selection in this insect is dominated primarily by hereditary factors on which the influences affecting the individual have merely an ephemeral and relatively insignificant effect. An absolute demonstration of the cumulative effect of environmental influences on the choice of the host requires in our opinion much more extensive and convincing evidence than that so far offered by any of the supporters of that view.

THE INTRODUCTION OF BRACONID PARASITES OF *DIATRAEA SACCHARALIS*, FABR., INTO CERTAIN OF THE WEST INDIAN ISLANDS.

By Harold E. Box,

Entomologist, Agricultural Experiment Station, Tucumán, Argentina.

(Plate XVIII.)

While engaged as entomologist to the Central Aguirre Sugar Company, owners of some 12,000 acres of sugar-cane lands situated on the south coast of Porto Rico, the writer continually recommended the importation into that island of certain larval parasites of *Diatraea saccharalis*, Fabricius (sugar-cane moth borer), as the one species indigenous to Porto Rico—*Lixophaga* (*Euzenilliopsis*) *diatraeae*, Townsend (Tachinidae)—alone, does not effect a sufficiently high percentage of control of the island's major sugar-cane pest.

The parasites that appeared to offer the most promising results were certain neotropical species of *Ipobracon* and *Microdus* (Braconidae), as hitherto no Hymenopterous parasites of the larvae of *Diatraea* were known in Porto Rico, though a species closely related to *Microdus* (*Bassus stigmaterus*, Cresson) occurs to some extent in Cuba.

In 1924 and 1925 the writer had taken with him from British Guiana to Porto Rico on two separate occasions small consignments of larvae and cocoons of *Ipobracon grenadensis*, Ashmead* (Pl. xviii, fig. 1) and *Microdus diatraeae*, Turner (Bull. Ent. Res., xvi, Jan. 1926, p. 264), cold storage methods being adopted for keeping the material in good condition during transit, and as a result of these introductions the latter became established as a larval parasite of *Diatraea* on the south coast of Porto Rico. Field recoveries were made of three cocoons and two parasitised borers during February and March, 1925, and four more cocoons during December 1926, on one of the properties of the Central Aguirre Sugar Company not far from where the original releases had been made. The *Microdus* cocoons and the parasitised borers† thus found were invariably within *Diatraea* tunnels in young canes showing the characteristic " deadhearts."

Owing to the successful establishment of the *Microdus*, and taking into consideration the long time due to elapse before these parasites could reasonably be expected to effect any marked control of *Diatraea*, it was considered advisable to proceed further with the work of importing Braconid parasites, and in 1926 the writer was sent to Venezuela, where, from April until July, he was engaged in shipping adults of *Ipobracon grenadensis* (determined through the courtesy of the Imperial Bureau of Entomology) and others of the same genus to Porto Rico. As a result of this trip several hundreds of these parasites were introduced, the material from the first few consignments being used in attempted breeding work, which did not give good results, largely owing to the absence at the receiving end of anyone able to devote the necessary time for their care, etc. The parasites received in all of the later consignments were released direct into borer-infested canefields.

In 1927 another visit was made to South America, and in this project the Central Aguirre Sugar Company received the co-operation of the Department of Agriculture of Porto Rico, which deputed Mr. Luis A. Catoni (Chief Quarantine Inspector) to

* This species has been referred to as *Iphiaulax medianus*, Cameron, in most of the works dealing with it in British Guiana and the West Indies.

† *Microdus* is an internal parasite of its host, and borers can only be recognised as parasitised when the contained *Microdus* larva has reached a fairly advanced stage in its development, when the host becomes very sick-looking and flabby. The larva of *Ipobracon*, however, works externally, feeding upon its host by suction through the abdominal integument.

accompany the writer to Venezuela and learn the business of collecting and despatching the parasites. After sending off three consignments (763 females and an uncounted number of males, mostly *I. grenadensis*) to Porto Rico, the writer left Mr. Catoni to continue shipping from Venezuela, himself proceeding on to British Guiana, where at certain seasons *Ipobracon* is far more abundant than it was found to be in Venezuela. It was believed that it would be quite practicable to ship parasites from Demerara by the same means that were employed by the writer in shipping them from Venezuela, i.e., as adults in wire-mesh cages, and, allowing for a higher percentage of mortality due to the much longer time required for the journey, still to receive in Porto Rico a larger number of parasites than could be obtained from Venezuela. This idea was later confirmed, as it was found that over 50 per cent. of the adult females could survive the 10–12 days' journey from Demerara to Porto Rico. It is worth placing on record that of the 1,638 adult female *Ipobracon* collected by the writer and Mr. Catoni in Venezuela, 1,215 (about 80 per cent.) arrived in good condition at Central Aguirre, the time required being from 4 to 8 days, according to the date on which the insects were collected.*

Leaving La Guayra, Venezuela, on 17th February 1927, the writer arrived at Trinidad, *en route* for Demerara, three days later, and took the opportunity of visiting the Imperial College of Tropical Agriculture and renewing his acquaintance with Professor H. A. Ballou. In the course of conversation with Prof. Ballou, the writer mentioned that those of the British West Indian islands which suffer from the attacks of sugar-cane moth borers ought to engage in projects of a similar nature to those being undertaken by the Aguirre interests in Porto Rico. The island of Barbados, in particular, was mentioned as likely to offer conditions favourable for the control of cane borers by biological methods.† The writer then suggested that in the event of the agricultural authorities in Barbados being interested in securing some of these parasites for trial, he would be pleased to send a consignment of them from British Guiana. Prof. Ballou expressed the opinion that the Government of Barbados would willingly give a fair trial to any method that might control insect pests in the island, and promised to get into early communication with Professor J. P. d'Albuquerque, Director of Science and Agriculture, Barbados.

Continuing the journey to British Guiana, the writer remained in that country from 23rd February until 17th March (except for a short visit to Nickerie, Dutch Guiana), and during this time despatched two cages of Braconids, mostly *I. grenadensis*, to Venezuela, where Mr. Catoni received them and attended to their transhipment by first opportunity to Porto Rico.

Mention should here be made of the excellent manner in which Mr. J. R. C. Gordon, Manager of Plantation "Waterloo," Nickerie, D.G., attends to the problem of controlling *Diatraea* on the estates in his charge. In addition to planting the seed-cane under a few inches of soil in such a manner that contained borers are unable to complete their metamorphosis and escape to infest new canes, limiting the burning of canefields, and adopting a general sanitary scheme of growing the canes, Mr. Gordon had systematically gone over his property and completely eradicated the razor-grass (*Paspalum virgatum*), which serves as a breeding-ground for borers when it occurs in masses near canefields. Mr. Gordon is to be congratulated on the splendid condition of his plantations, due in a slight measure to the adoption of the writer's recommendations (op. cit. pp. 256–257), which do not appear to be carried out by his neighbours in British territory, where, paradoxically, the recommendations were originally made.

* The parasites were collected for the four successive days previous to the scheduled date of sailing of any steamer for Porto Rico.

† Trinidad, it seems, does not suffer from *Diatraea saccharalis* to the extent prevailing in the other islands, owing no doubt to the presence there of numerous parasites upon the larval as well as the egg stage, and the conditions under which cane is grown (among which non-burning of the canefields should be mentioned) in Trinidad proving favourable for their natural propagation.

While in British Guiana the writer received from Prof. d'Albuquerque a most courteous cablegram accepting his offer to send a consignment of *Diatraea* parasites to Barbados.

When the writer left Demerara there was no immediate steamer connection at Trinidad for Venezuela, and it was found that a stop-over of seven days was necessary

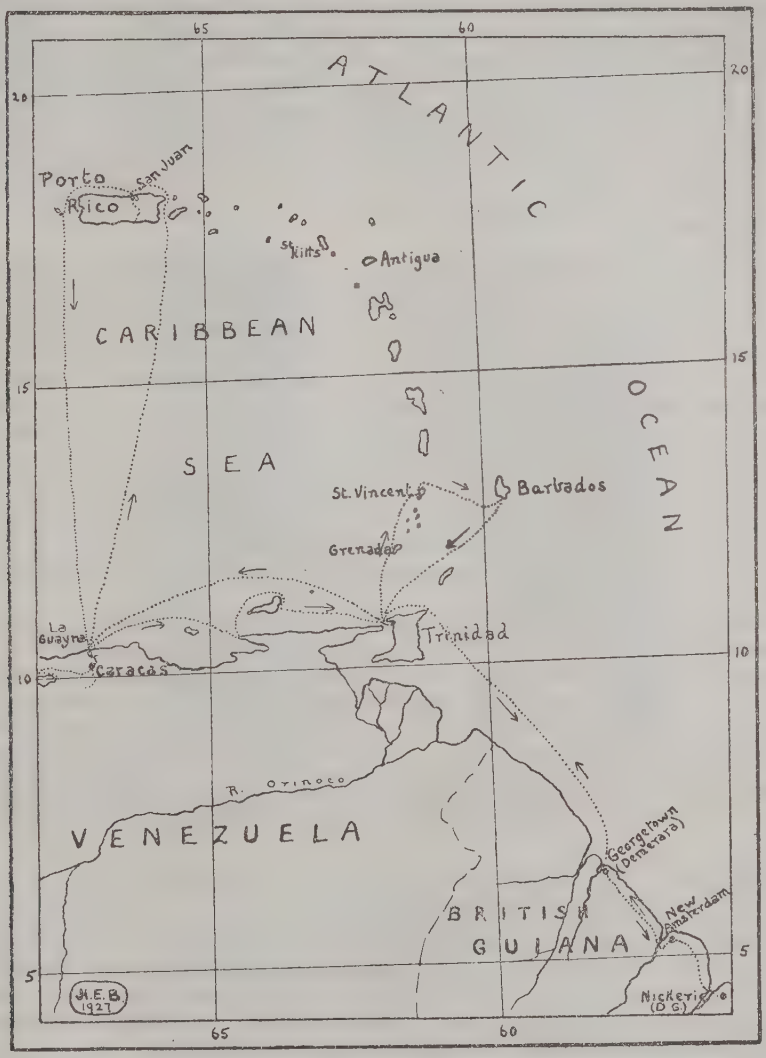

Fig. 1. Sketch-map showing the author's route.

before a suitable sailing for La Guayra, and as he was taking with him several cages of Braconids for Porto Rico as well as one containing about 150 females of *Ipobracon* and *Microdus* for Barbados, he decided, after consultation with Prof. Ballou in

Trinidad, to go on to Barbados and hand over the parasites personally to the Science and Agriculture Department at Bridgetown. It was while in Trinidad on this occasion that Prof. Ballou expressed to the writer his interest in securing some of these parasites for distribution in Antigua and St. Kitts, in both of which islands *Diatraea* takes heavy toll of the sugar industry. As the writer, when in British Guiana, had received considerable aid in his parasite collecting work from Messrs. S. Davson & Company, whose many courtesies are here acknowlegded with the writer's sincere thanks, he advised Prof. Ballou to get into touch with this firm, upon whose extensive properties in Berbice most of the parasites had been collected, suggesting that Mr. Seerkissoon, in charge of the entomological laboratories and insect-pest control work for Messrs. Davson & Co., be permitted to send some *Ipobracon* and *Microdus* for subsequent distribution in Antigua and St. Kitts. Thanks to the obliging manner in which the Director (Mr. W. M. B. Shields) of Messrs. Davson & Co. at New Amsterdam, acceded to this request, and the very practical aid of Mr. Seerkissoon, a fairly large consignment of these Braconids was later shipped to Trinidad, whence Prof. Ballou took them to Antigua.

The writer cannot speak too highly of the courtesy of Professor d'Albuquerque, Mr. C. C. Skeete, and others of the Department of Science and Agriculture of Barbados, nor of the cordial and enthusiastic manner in which his ideas were received for controlling *Diatraea* and other insect pests in the island. A large field cage (Pl. xviii, fig. 2) was immediately prepared at Codrington and stocked with canes that had been artificially infested with *Diatraea* to serve for propagating the Braconids. These cages were also provided with numerous growing plants of *Cordia interrupta* (Pl. xviii, fig. 3), which have the property of secreting a sweet honey-dew from glands on the lower surface of the leaves; this honey-dew is much favoured by the adults of *Ipobracon*, and in British Guiana hundreds of these wasps may sometimes be seen flying around and settling upon the *Cordia* bushes that occur commonly in the neighbourhood of the canefields. When in Trinidad the writer drew the attention of Prof. Ballou to this feature, and suggested that these plants should be obtained and grown around the canefields in the northern islands wherever it was intended to release parasites.

At Codrington the parasites commenced to oviposit upon the borers immediately they were liberated into the cage with them, in one instance it being observed that the Braconid had actually pierced the rind of a thick cane with the saw-like sheath of its ovipositor in order to deposit its egg upon the larva concealed within. It soon became evident that with proper care and attention, and other conditions being favourable, several successive generations could be reared in the cage for distribution to various parts of the island; but the readiness with which these Braconids attacked the larvae of *Diatraea* in the cage suggested that under normal field conditions they would behave in a similar manner, in which case the cage breeding might well be dispensed with.

This suggested the desirability of making further importations of the parasites from British Guiana for direct release into the canefields, and letters were written to Mr. Shields and Mr. Seerkissoon arranging for advantage to be taken of the seasons when *Ipobracon* is most abundant in Berbice, to ship them to Barbados. Copies were sent to Prof. Ballou in Trinidad to aid him in his projected work for Antigua. The writer has since learned that a consignment of two thousand female *Ipobracon* was sent from Demerara, over 80 per cent. of them arriving in fine condition at Barbados, where presumably they were used in the manner indicated.

The type of cage (fig. 2) which the writer has found convenient and practicable for shipping adult Braconids was designed in 1926 for sending *Ipobracon* from Venezuela to Porto Rico, and proved so serviceable that it was used throughout the various parasite importations described above. A cylinder, 25 in. high, made by securing two sides of a piece of wire mosquito-mesh, 25 in. by 32 in., is covered at one end with

a wire-mesh meat-cover of suitable diameter, all the fixtures being made by means of brass paper fasteners. The open end of the cylinder is covered by a piece of black cloth tied across with string. A small slit 2 in. long is cut in the cloth so that a glass tube can be inserted into the cage. The parasites are collected in the tube (the writer employs one measuring 3 in. by 1 in.), either direct from their food-plant or from the collecting-net, and rapidly fly into the cage owing to their habit of strong positive phototropism. When about 250 parasites have been caught in this manner, the slit in the black cloth is stitched up, and both ends of the cage covered with brown packing-paper tied with cord (fig. 2). For the nourishment of the insects during their journey a pad of absorbent cotton is tied over the cage in close contact with the side; this pad is then soaked with sweetened water, and all that is required is to keep the pad moist to ensure that the insects obtain their necessary food.

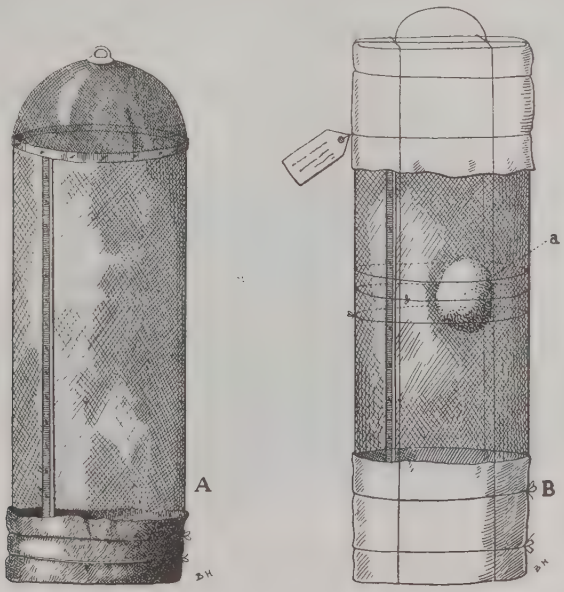

Fig. 2. Type of cage designed by the author for shipping adult Braconids: A, cage in use; B, cage packed for shipment; *a*, pad of cottonwool soaked in sweetened water.

An experiment was carried out to determine whether the parasites would travel better when in complete darkness than when transported on open deck in the manner illustrated in fig. 2. The side of the cage in this test was wrapped round with thick packing paper, and the cotton pad received no attention further than being thoroughly soaked before packing. It was found that practically no difference was observable in the percentage of adults surviving transit when shipped in this manner as compared with those sent in " light " cages.

While it is too early to say what are the results of this preliminary work in the West Indies, it cannot be denied that the methods outlined above offer possibilities of securing at least a partial control of *Diatraea saccharalis*. Considering the very severe nature of the losses sustained in the islands through this pest, varying from 10 to 25 per cent., and the practical failure of all other measures to secure control, it seems that the work which has now been started ought to be followed up wherever it seems likely to give good results.

In British Guiana both *Ipobracon* and *Microdus* are extremely abundant, though the percentage of parasitism by them seldom exceeds 5 per cent. of all borers, in spite of the custom universal in that Colony of burning the canefields before cutting. Were this custom abandoned (as it ought to be), the writer believes that within quite a short time the status of the cane borer in British Guiana would be reduced till it approached that of Trinidad.

Introduced into a country like Barbados, where there is an abundance of potential hosts, and no factor like the above to hinder the rapid multiplication of these parasites, the writer believes that *Ipobracon grenadensis* at least would rapidly accustom itself to any climatic changes, for it must be remembered that in addition to occurring in abundance on the tropical coastlands of British Guiana, this same species occurs in Grenada, as well as in the highlands of Venezuela in the vicinity of Caracas. And on similar grounds there is every reason to believe that this parasite will become established in Porto Rico and Antigua, where it has now been introduced. The fact that the *Microdus* became so soon established in Porto Rico makes it almost certain that it would also establish itself in other West Indian islands.

In order to give these Braconids every opportunity of propagating in a state of nature, *Cordia interrupta* should be grown in the hedges around the canefields in each of the countries where introductions have been made, and for this reason the writer took with him to Porto Rico a supply of the seed, which it is hoped will be planted and the resulting bushes widely distributed. In addition to providing a very necessary feeding ground for imported Braconids, these plants should serve to encourage indigenous parasites, such as *Tiphia parallela* in Barbados, and other Scoliids in Porto Rico.

The writer wishes to emphasise that the work described in this paper should be considered as merely preliminary in nature, and judging by what has now been accomplished in this direction, there is every reason to believe that it will be followed up by other introductions, among which that of the Tachinid, *Lixophaga diatraeae*, should come foremost. Based upon what the writer has observed of the efficiency of this parasite in Porto Rico, there seems to him no reason why it should not give good economic results in Barbados and other of the British West Indian islands.

Fig. 1. *Ipobracon grenadensis*, Ashm. (× 2); a parasite of the larva of *Diatraea saccharalis*.

Fig. 2. Large field-cage for breeding parasites of *Diatraea*.

Fig. 3. Interior of cage, showing arrangement of infested canes and growing plants of *Cordia interrupta*.

THREE NEW SOUTH AFRICAN *XENOPSYLLA* (SIPHONAPT.).

By Dr. A. Ingram.

The examination of a collection of fleas, obtained during the last two years in the course of the investigation of plague amongst the rodents of the South African veld, has resulted in the finding of three new species of *Xenopsylla*, which are described below.

My thanks are again due to Dr. K. Jordan and to Dr. G. A. K. Marshall for advice and help kindly given to me.

Xenopsylla piriei, sp. nov.

Closely resembles *X. eridos*, Roths., the females, indeed, being apparently indistinguishable.

♂. With the exception of the modified segments, the general features of the male also bear a close resemblance to those of *eridos*.

Fig. 1. Processes of the clasper: A, *Xenopsylla piriei*, sp. n.; B, *X. eridos*, Roths.

Modified segments. The eighth segment bears about ten bristles on each side, of which the most apically placed is longer, as compared with the bristles immediately proximal to it, than is the similarly situated bristle in *eridos*. The outer process of the clasper is more cylindrical in shape and relatively longer than that of *eridos*, the bristles along its upper border are also less curved and are more evenly distributed from base to apex than is the case in *eridos* (fig. 1). The horizontal (outer) limb of the ninth sternite is less obtuse apically than that of *eridos*; it is also relatively slightly

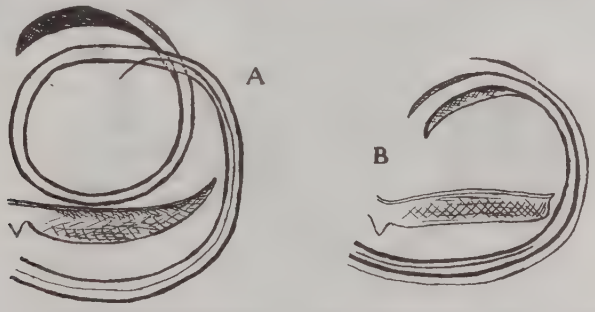

Fig. 2. Spiral of penis and internal plate of: A, *Xenopsylla piriei*, sp. n.; B, *X. eridos* Roths.

longer, and the hairs on its ventral margin are equally spaced; in *eridos* the hairs on the ventral margin tend to be grouped in the middle. The internal plate of the penis is longer than that of *eridos* and is pointed at its proximal end, which is turned upwards; the internal plate of the penis in *eridos* when viewed laterally is truncate at its proximal end, which is not turned upwards (fig. 2). The process at the upper apical angle of the paramere of the new species is more hook-shaped than that of

eridos, and there is no chitinous thickening proximally along the dorsal margin of the paramere ; in *eridos* there is present a distinct chitinous thickening, which extends from the less curved process at the upper apical angle proximally along the dorsal margin of the paramere (fig. 3). The spiral of the penis is longer than that of *eridos* and is twisted proximally into a double coil, frequently heavily chitinised at the proximal ends ; the spiral of the penis in *eridos* shows only a single coil, and its proximal ends are not usually heavily chitinised (fig. 2).

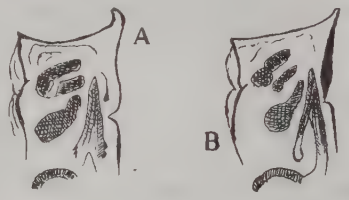

Fig. 3. Paramere of : A, *X. piriei* ; B, *X. eridos*.

Numerous specimens of males and females collected from the nests of gerbilles (*Tatera lobengulae*) in the Transvaal and from the nests and burrows of Karroo rats (*Mystomys broomi* and *Parotomys luteolus*) and of gerbilles (*Desmodillus auricularis*) in the Steynsburg and Calvinia Districts of the Cape Province, April 1925 to September 1926.

The species is named after my colleague, Dr. J. H. Harvey Pirie, who has shown great interest in the species of fleas found on the veld rodents and has frequently assisted in the capture of fleas.

Xenopsylla hirsuta, sp. nov.

This species appears to be related to *X. crinita*, J. & R., the male having a row of strongly developed bristles subapically on the eighth sternite of the abdomen and having the antepygidial bristle arising from an ill-defined tubercle. The shape of the movable processes of the clasper, however, is quite different in the two species.

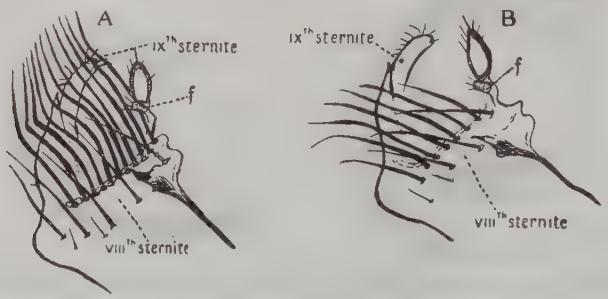

Fig. 4. Eighth and ninth sternites and clasper of : A, *X. sulcata*, sp. n. ; B, *X. hirsuta*, sp. n.

Head. Covered with small hairs and somewhat abruptly rounded in front of the suture. Eye well-developed and pigmented. A single bristle above the antennal groove and 4–5 bristles on each side in the subapical row of the occiput. The rostrum scarcely reaches the apex of the fore coxa. The dorsal groove of the male is very deep and extends backwards to the apex of the mesonotum.

Thorax. The nota bear each a postmedian row of 10–12 bristles on the two sides together. There are one and three bristles on the mesepisternum and mesepimeron, respectively, while the metepisternum and metasternum have each a single bristle, and the metepimeron has a row of 5 bristles anteriorly and a row of 5–6 bristles posteriorly.

Legs. The fore coxa bears on its outer side about 20 bristles. The hind coxa has on its anterior margin and on its outer side from 25 to 30 bristles, and a row of 8–10 small spines on its inner surface. The hind femur has a very distinct sub-basal tooth. The longest apical bristle of the hind tibia does not reach the apex of the first hind tarsal segment. The longest apical bristle of the first segment of the hind tarsus does not quite reach the apex of the second, and the longest apical bristle of the second segment extends to the middle of the fifth or beyond that point.

Abdomen. There are 6–8 hairs on the first tergite in the irregular row and 8 bristles in the postmedian row, counting both sides together. The second tergite has a postmedian row of 4–16 bristles, and the postmedian row of tergites iii to vii is composed of 14 bristles, both sides being counted together. There are two bristles close to the middle line on sternite ii and frequently two more on each side at some distance from the middle ones; there are usually 6 bristles, counting both sides together, on each of the sternites iii to vii. The antepygidial bristle, placed close to the posterior margin of the seventh tergite, arises from a slight pedicle.

Modified segments.

♂. The eighth sternite has on each side 6–7 bristles and a sub-apical row of 6 stout bristles, which gradually increase in size from dorsum to venter and are curved in a ventral direction (fig. 4). There is no row of bristles, as in *crinita*, at the posterior margin of the ninth tergite behind the pygidium, but the lateral bristle at each end of the row of small hairs in this situation is long and arises from a small pedicle. The outer movable process (*f*) of the clasper is square-shaped and remarkably short, bearing

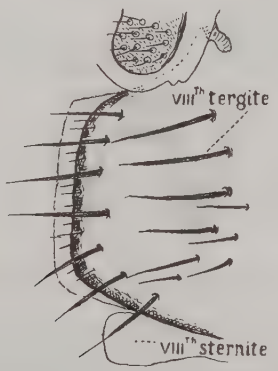

Fig. 5. Eighth sternite of *Xenopsylla hirsuta*, sp. n.

apically three or four slender hairs; the inner process is ovoid in shape, narrowing slightly towards apex and base and carrying an apical bristle and a few hairs on each side (fig. 4). The manubrium is slender and pointed at its proximal end. The ninth sternite, like that of *crinita*, is parallel-sided and rounded off at its apex, which is curved upwards. The internal plate of the penis expands proximally to a broad and rounded end.

♀. The distal margin of the eighth tergite is not sinuate but is gently curved, it carries laterally 8–9 bristles and 7 additional bristles close to the distal and ventral margins (fig. 5). The eight sternite is rather broad and is bluntly rounded apically. The stylet is conical and short, about three times as long as it is broad. The " head " of the spermatheca is large, much wider than the " tail," its longer diameter being placed somewhat obliquely to the junction of the " head " with the " tail " (fig. 6).

Length, ♀ (average of a dozen specimens) 2·2 mm., ♂ 1·6 mm. Numerous specimens of males and females taken in the nests of Cape gerbilles (*Tatera afer*) at Bellville, Cape Province, by Mr. T. Muller in March and April, 1926.

Xenopsylla sulcata, sp. nov.

Closely related to the previous species, the females being difficult to distinguish ; the males, however, are readily separated by the presence of stouter and more numerous bristles on the eighth sternite and by the division of the first abdominal tergite into lobes.

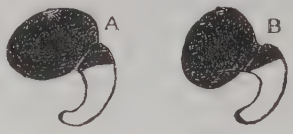

Fig. 6. Spermatheca of : A, *Xenopsylla hirsuta,* sp. n. ; B, *X. sulcata,* sp. n.

Head. Covered with small hairs and rather abruptly curved beyond the suture. Eye well developed and pigmented. Hairs and bristles as in *hirsuta.* Rostrum not reaching the apex of the fore coxa. The dorsal groove of the male very deep, extending to the apex of the mesonotum and traceable across the metanotum to the sulcus between the lobes of the first abdominal tergite.

Thorax. Hairs and bristles as in *hirsuta,* usually one or two fewer bristles on the nota of the male.

Legs. As in *hirsuta,* except that the longest bristle of the first segment of the hind tarsus usually extends to the tip of the second segment.

Fig. 7. Dorsal view of first abdominal tergite of *Xenopsylla sulcata,* sp. n., ♂

Abdomen. The first tergite of the female has 6–8 slender bristles in the irregular row and 8 bristles in the postmedian row, counting the two sides together. In the male the first tergite has three small bristles in the irregular row on each side and is divided distally into two lobes, which are separated by a rather broad groove. Each of these lobes is strongly chitinised apically and bears a tuft of about a dozen long and stout bristles (fig. 7). There is a postmedian row of 13–14 bristles, counting both sides together, on each of the tergites ii to vii. The second sternite has two bristles (one on each side) mesially and two additional bristles on each side widely separated from the middle pair. There are 6–8 bristles on each of the sternites iii to vii. The antepygidial bristle, slightly shorter than the second hind-tarsal segment, rises from a small pedicle close to the posterior margin of the seventh tergite.

Modified segments.

♂. The eighth sternite has on each side five stout bristles in a curved row with one or two smaller bristles in front of this row ; subapically it bears a closely-set row of 11–12 very long and stout bristles on each side, the bristles in the middle of this row being curved in an S-shaped manner. The processes of the clasper are difficult to see owing to the palisade-like row of bristles on the eighth sternite : they appear, however, to be similar to those of *hirsuta*, the outer process (*f*) being extremely short and square-shaped, with a few fine hairs at its apex ; the inner is ovoid in shape, tapering gradually towards apex and base and bearing apically a bristle and on each side three or four hairs (fig. 4). As in *hirsuta* there is no row of bristles on the ninth tergite behind the pygidium, but the bristle on each side of the row of slender hairs is very long, as long as the antepygidial bristle, and rises from a small pedicle. The ninth sternite resembles that of *crinita*, being parallel-sided with an upwardly-curved and rounded apex.

♀. The contour of the eighth tergite is like that of *hirsuta* and carries laterally and subapically the same number of bristles on each side. The stylet is also similar to that of *hirsuta*. The spermatheca is slightly different in shape from that of *hirsuta*, the " head " having its longer diameter placed more perpendicularly to the junction of the " head " with the " tail " and being more spherical in shape (fig. 7).

Length, ♀ (average of twelve specimens) 1·8 mm., ♂ 1·8 mm. Several specimens of males and females collected from the nests of Cape gerbilles (*Tatera afer*) by Mr. J. M. Koch at Citrusdal, Cape Province, September 1927.

The females of this species may usually be distinguished from those of *hirsuta* by their smaller size and by the shape of the spermatheca.

THE RELATION OF CERTAIN ALGAE TO BREEDING PLACES OF MOSQUITOS IN QUEENSLAND.*

By Ronald Hamlyn-Harris, D.Sc.,
City Entomologist.

For some time past the relation of certain aquatic plants to mosquito control has been exercising the minds of biologists, but up to the present time, from a really practical standpoint, little has been achieved.

It is universally recognised that the extermination of mosquitos, but more especially of the Anophelines, presents many difficulties, and research into the biological side of the question is more than justified in view of the big problems of control confronting entomologists at the present time and the expensive methods in vogue.

It is certainly an outstanding fact, which every mosquito survey serves to emphasize, that numerous potential breeding-places exist which apparently are not selected. Such places are by no means uncommon, nor are they restricted to waters provided with aquatic vegetation.

Then there is the question of seasonal occurrence, when long periods of mosquito inactivity have to be taken into consideration. Some types of mosquitos, although undoubtedly possessing this characteristic, nevertheless continue to breed in a desultory kind of way throughout the greater part of the year, and their frequent choice of breeding-places of a somewhat abnormal character needs explanation. Unless these facts are taken into consideration, the avoidance of such waters at specific times may be misinterpreted.

It is now generally recognised that mosquito control really means separate control measures directed against each individual type of mosquito, and where there are many of these, general rules cannot be made for application to all species indiscriminately, nor is such generalisation wise, even if it were possible to adopt it.

It is difficult to say at the present stage whether in any case much good can result from the application of biological methods of control, but it is certainly not in the best interests of the Public to make promises leading them to believe in the efficacy of control measures which in actual practice are incapable of fulfilment.[3]

The fact that the same mosquito will sometimes select widely different breeding-places and associate with other mosquitos under rare and exceptional circumstances, is evidence that if the usual preferential breeding-places are not available the mosquito in question will select the next best breeding-place in order of preference, such breeding-places as H. R. Carter[5] refers to as compulsory.

Seasonal Association of Mosquitos.

At certain times of the year we find *Lutzia halifaxi*, Theo., which breeds for preference in gully-traps of the city and is apparently attracted by foul water, associated with *Culex annulirostris*, Skuse, in muddy pools of fresh water in the outlying districts of Brisbane; and we find *Aëdes* (*O.*) *alboannulatus*, Macq., occasionally in brackish water, when as a rule it prefers fresh water, principally the larger water-holes and swamps. In February 1927 *Aëdes* (*O.*) *vittiger*, Skuse, was found breeding, among other places, in fresh water along a natural watercourse, close to a culvert at Sherwood; by April the water had changed its character from an acid to alkaline and *Lutzia halifaxi* had taken its place, nor has *A. vittiger* been found there since, though the association of *Anopheles* (*Myzomyia*) *annulipes*, Walker, and *Culex*

* From the Entomological Section of the Department of Health, Brisbane City Council.

annulirostris was maintained throughout the season in the same water. Many other instances might be cited, for in a country subject to drought such instances are numerous. But the type of mosquito is not by any means the only determining factor. The distribution of mosquitos, certainly in South Queensland, varies with the seasons and the change of the physical and chemical composition of the waters. During the winter months there appears to be a distinct tendency on the part of certain mosquitos to extend their activities and select breeding-places from choice, which at other seasons of the year are either avoided or selected only compulsorily ; whilst in the laboratory, the activities of the two domestic mosquitos are almost entirely suspended. As the summer advances it has been found that these natural water-holes show a paucity of oxygen and carbon dioxide, which tends to destroy the lower forms of vegetable life upon which the larvae feed ; also at this time of the year natural larval destructors, all things being equal, are at their best ; these two widely different factors alone suggest lines for further research.

Algae and Anophelines.

It is well known that direct sunlight has a great influence on the growth of algae,[6] and this, together with the presence of free carbon dioxide, produces ideal breeding-places for all Queensland Anophelines ; the presence of quantities of *Spirogyra nitida*, and other small confervae wherever found, invariably leads to the occurrence of Anophelines in this area. Observations in the field indicate that the presence of larval food is the determining factor for breeding places of selection, and if this applies to Anophelines, why not to other mosquitos?

Characeae and Mosquito Control.

In 1919 Caballero[4] stated that " *Chara foetida* caused the death of mosquito larvae by asphyxiation," and since then there has always been a hope that these plants might be of direct service in the biological control of breeding-places ; some have even gone so far as to take it for a foregone conclusion that the general use of Charophytes would greatly assist in solving the mosquito problem.[14] Since Caballero first made his observations, opportunities have presented themselves for testing the efficacy of *Chara foetida*, but the finding of the Malaria Commission in Spain,[12] operating in 1924, is in the negative.

T. B. Blow's personal observations made in Madagascar,[13] that certain Charophytes appeared to inhibit mosquito development, seemed at first sight to be very convincing. In a personal letter he writes : " In a large pond, full of a fine crop of *Chara zeylandica* not a larva was to be seen, while near, other waters were full of larvae." Unfortunately this is only a negative finding and does not prove anything. Blow's subsequent investigations[2] have convinced him that Charophytes have no larvicidal properties, for not even the glucoside prepared from the dried plant showed any larvicidal action in water of 1–200.

Howard[9] in a recent paper on "Mosquito work during 1925" gives us the following information : "During the year 1925 Tarnogradski, working in the Northern Caucasus, found that many of the breeeding-places of *Anopheles maculipennis* were heavily overgrown with *Chara*. M. E. MacGregor working in Surrey emphasizes the futility of *Chara* against Anophelines, confirming his 1924 conclusions."[10] The finding of no less than three species of mosquitos breeding side by side in slowly running water in among *Nitella* has been recorded,[7] and as this species has since been identified by Groves as *N. phauloteles*, it is the more noteworthy, because it so completely upsets the theory advocated by Buhot in the Proc. Royal Society of Queensland[3] that this plant would prove of value in mosquito control.

Natural Habitat of Characeae.*

In the various streams in which specimens of *Chara benthamii* (Br.), *Nitella phauloteles* (Groves), and *Nitella diffusa* (Br.), have been taken, these species grow most profusely in running water, nor do they seem in any way to be inconvenienced by the rapidity with which the water passes over them. They are to be found in those parts of the brook where the water is freshest and most likely to be in constant motion, and although occasionally plants may occur at the sides of a stream, it will always be noticed that the water is kept fresh by an under-current of some sort, or perhaps by some such means as wind beating constantly against the surface of waters situated in an exposed position. The depth from the water surface at which *Nitella* occurs varies very much according to circumstances; *Nitella* has repeatedly been found in this area thriving and fruiting within an inch of the surface, though its actual preference seems to be for a depth of about 18 inches, seldom more. It has been stated that the plant dies unless covered by water, but this is apparently not the case, as a sample of *Nitella* in a shallow glass vessel not more than 4 in. in depth is now actually fruiting, the whorls growing above the water. If portions of the plant become dislodged in flood waters, which frequently happens, they are carried down stream and settle wherever the waters deposit them, and as long as the water remains comparatively fresh and in circulation, *Nitella* will grow and develop; but as soon as the water becomes stagnant and polluted, the plant commences to decompose rapidly until it actually disappears, except perhaps for the spore-capsules, which would naturally fall to the bottom. There seems thus no reason to believe that there exist any Charophytes capable of excreting toxins in sufficient quantities to kill mosquito larvae. Under natural conditions many kinds of small organisms and larvae of various orders live and thrive in close proximity to these plants. Numerous Protozoa and Coelenterates, Mollusca, and larvae of beetles and flies in particular, abound, proving that Characeae are not in any way detrimental to these forms of life.

Natural Waters and the Soil they overlie.

The large number of water-holes in the Brisbane area not being selected as breeding-places by mosquitos has been noted; some of these contain no sign of life of any sort, such being more frequently than not extremely acid waters, though the pH varies considerably with the seasons especially after rainfall, and occurring on a yellow clay subsoil contain salts of alumina and incidentally ferrous oxide in solution, which would tend to destroy larval food.

The aquatic plants found in fresh water in the Brisbane area† are :—

Jussiaea repens (Clove Strip or Yellow Primose), *Hydrilla verticillata* (Water Thyme), *Eichhornia speciosa* (Water Hyacinth), *Ceratophyllum demersum* (Hornwort), *Lemna oligorrhiza* (Duckweed), *Azolla rubra* (Red Azolla), *Najas tenuifolia* (Water Nymph), *Ottelia ovalifolia* (Swamp Lily), *Triglochin procera* (Water Ribbons), *Utricularia flexuosa* (Bladderwort), *Nasturtium officinale* (Water Cress), *Chara benthami*, *Nitella phauloteles*, and *Nitella diffusa*; and less frequently :—*Myriophyllum variaefolium* (Water Milfoil), *Potamogeton crispus* (Curled Pondweed), *P. tricarinatus* (Floating Pondweed), *P. javanicus* (Small-leaved Pondweed), and *Vallisneria spiralis* (Eel Grass). The following also occur :—*Philydrum lanuginosum*, *Typha angustifolia* (Bulrush), *Nymphaea gigantea* (Blue Water Lily), and *Limnanthemum indicum* (Fringed Water Lily).

* In order to avoid the possibility of error, specimens of all Characeae used in these experiments were submitted to Mr. Jas. Groves (Isle of Wight) for identification, and his assistance in this direction is much appreciated.

† Best thanks are due to Mr. C. T. White, Government Botanist, for his kindness in identifying specimens submitted to him from time to time.

It is possible that these plants may be useful indicators of the types of waters in which they grow, but at present nothing is known of this phase of the subject with regard to Queensland ; the question opens up almost limitless possibilities of research.

It is understandable that mosquitos may seldom mature in (and possibly fail to select) such places rich in vegetation, when it is realised that, owing to the excellent aeration of the waters, plentiful supplies of aquatic insects abound, which may play a greater part in mosquito control than has hitherto been thought possible. During a survey of vacant lands at St. Lucia a fresh-water swamp of about an acre in extent was found at a lower level than the road, receiving all the surface drainage of the surrounding lands. In the deeper parts of this swamp *Nitella diffusa* occurred clinging to the sides of the bank with *Hydrilla* and *Utricularia* intertwined, and a few feet away *Culex annulirostris* and *Aëdes alboannulatus* were found breeding in a hydrogen-ion concentration of 6·8. This observation was made on 14th July 1926. When a re-examination of this water was made nine months afterwards, conditions had not materially altered, except that *A. alboannulatus*, which had disappeared, was replaced by *Anopheles annulipes*, though *C. annulirostris* continued to breed uninterruptedly.

Harris' researches on salts and chemical equilibrium in solutions[8] are noteworthy, and as toxicity in soil is dependent upon, not only the amount of recognised toxic salt present, but on the proportion in which it and other salts are available at the same time, it concerns us to no small extent that a whole host of contributing factors cause an incessant change in the position of the soluble salts and either bring about a complete state of equilibrium in our waters or the reverse ; and unless we know something of the nature of the water and the soil which underlies it, it seems to be futile to attempt to attribute toxicity in natural waters, if it exists, to the growth in them of any one particular plant, or to some other cause insufficiently understood. We know that changes in temperature cause changes in the solubility of salts, and that this, together with the increased presence of oxygen and carbon dioxide through rain, disturbs the equilibrium of the compounds by changing the solubility and causing the oxidation of certain compounds. Harris points out that these and numerous other factors cause the soil solution constantly to vary in concentration and composition. So that the absence or presence of mosquito larvae may be mainly dependent upon the supply of larval food, and the results obtained in several laboratory experiments go to confirm this view.

The presence of large quantities of iron salts in solution is another factor which cannot be ignored ; that much iron is present is evident from the ferric salts that are deposited in large quantities as a slimy flocculent mass on certain plants, of which *Chara* and *Nitella* seem to receive more than their fair share. Such waters mostly display an acid tendency, and range from 6·4 to 7 ; it is noteworthy that one seldom finds Culicine larvae in any natural waters of this type.

Natural Water in which Nitella grows.

At the commencement of these investigations it seemed necessary to have some idea of the composition of the waters of such a natural habitat as that of *Nitella*, and so water taken from a spot where both *N. phauloteles* and *N. diffusa* were found growing side by side in the creek at Doomben was examined; both these samples had a pH of 8·0 and, though taken $\frac{1}{4}$ of a mile apart, gave practically the same results, as follows, in parts per 100,000 :—Alkalinity 9·0, chlorides 13·0, hardness 3·8 ; the only difference being in the oxygen consumed (30 min. at 212° F.), 0·38 and 0·45, respectively.

The composition of such waters, of course, varies considerably. The presence of quantities of chlorides in the water was at first thought to be of some importance, hence the particular attention paid to them.

At that time the greater part of this small stream was in a state of stagnation; pollution was only just commencing, but nowhere except in fresh running water was *Nitella* to be found, and yet six months previously, when, after heavy rain, this water was constantly running, *Nitella* could be procured all along the water-course, and mosquito larvae were as much absent with *Nitella* as without it. During one of these inspections, a fairly deep stagnant pool was found in the bed of this creek; the water was polluted and had a deep brown colour, suggesting considerable quantities of colloidal organic matter, which should in ordinary circumstances have contained *Culex fatigans* larvae. But finding no life of any sort a sample of this water was taken and here is the analysis, in parts per 100,000:—Alkalinity 70·0, chlorides 25·4, hardness 8·8, oxygen consumed (30 min. at 212° F.) 0·76.

The results speak for themselves, the alkalinity is abnormal, the chlorine content unusually high, and the considerable amount of oxygen consumed suggests the presence of decomposition products; and although such isolated figures as these mean very little, they are some indication of the nature of water in which mosquitos will not breed. The hydrogen-ion concentration of this water was well in the region of 9·6, and mosquitos in this area have not been found breeding in water of which the pH exceeded 8·8, though numerous samples have been examined.

During a laboratory experiment, in order to fix the tolerance of *C. fatigans*, it was found that the eggs of this species hatched in pH 6·2 and in pH 9·1 but died soon afterwards. The toleration limit of the larvae seemed to range from 6·6 to 8·6, but then only when food was abundant.

There is no reason for supposing that the Nitellas choose one type of fresh water in preference to another; they occur in many parts of the City area and do not seem to be in any way restricted to certain water-courses or to certain types of water. Experience shows that they are "here to-day and gone to-morrow," that pollution destroys the plants, and that flooded waters carry them from one place to another. During periods of drought, to which we are constantly subject, stagnant waters soon become polluted and *Nitella* soon decomposes, leaving only a flocculent mass behind. In view of these facts alone *Nitella* could not possibly play a part in mosquito control, but in order to test the matter thoroughly various species of Charophytes have been under direct observation in the laboratory for some considerable time, and the results obtained are useful, though there is much room for further experimentation.

The Chemical Composition of Nitella.

First, with reference to the composition of *Nitella*, considerable quantities of *N. phauloteles* (Groves) and *N. diffusa* (Br.) were collected at different times from various local waters and kept in glass vessels. Two of these were selected for special observation, and after six months the plants became completely decomposed; the product deposited in the water during their period of growth was filtered and the ash examined, with the following results:—

	Nitella Ash.	
	phauloteles. Per cent.	*diffusa.* Per cent.
SiO_3	54·66	53·88
FeO_3	8·02	7·10
Al_2O_3	16·10	18·15
$CaCo_3$	3·63	3·21
$CaSo_4$	2·64	2·70
MgCo	6·22	6·50
NaCl	5·02	5·35
KCl	3·42	3·46
Water and Loss (by difference)	0·29	0·65
	100·00	100·00

It will be seen at a glance that there is very little difference in the composition of the two species, and it is important that this should be recognised. Possibly some of

the silica contained in both may be accounted for either by the glass vessel in which the waters had to be kept for long periods, or by a small amount of soil which may have been carried over.

The high percentage of alumina is striking, and if it is true that this salt is responsible for sufficient toxicity to destroy primitive types of plant life in natural waters, then the absence of food-stuffs in artificial receptacles such as we use in the laboratory is of the greatest significance and may explain why such waters are not selected as preferential breeding places.

Analysis of Water growing Nitella phauloteles under Laboratory Conditions.

	Parts per 100,000.
Total solids	76·4
Suspended solids	6·25
Silica	2·45
Iron and alumina	0·040
Ca. sulphate	13·6
Ca. carbonate	2·85
Mg. carbonate	7·52
Mg. chloride	15·83
Sodium chloride	22·00
Potassium chloride	5·80
Total So_4	9·59
Total Cl	27·9
Alkalinity as $CaCO_3$	11·8
Nitrites	0·0008
Nitrates	0·0060
Ammonium ammonia	0·0160
Albuminoid ammonia	0·0800
Oxygen consumed (30 min. at 212° F.)	0·660
pH	8·6

Average Composition of Brisbane River (Tap) Water for early Months of 1927.

	Parts per 100,000.
SiO_2	1·4
Iron and alumina	0·50
Ca. sulphate	1·4
Ca. carbonate	2·0
Mg. carbonate	1·5
Mg. chloride	3·0
NaCl and KCl	7·0

Experiments with Nitellas.

It is difficult, at the present stage of our knowledge, to say what factors are involved in creating stimuli responsible for egg-laying, but as investigations proceed one is inclined to think that the presence of food proves a powerful attraction, though how the female becomes aware of its presence is pure speculation. One thing seems fairly certain, and that is that a place once selected is chosen again and again and sometimes without apparent regard to its suitability. Some half dozen or more different specimens of both varieties of *Nitella*, other than those specially put aside for special observations, have been in the laboratory for the best part of twelve months. Both *Aëdes argenteus* and *C. fatigans* have, when available, had access to these waters, and *C. fatigans*, more especially, has not hesitated to select them at some time or other. Every vessel, with the exception of one containing *N. diffusa*, has been responsible for mature specimens, many of which, however, were so slow in development that food, in the shape of small quantities of dried blood and decaying leaves, was used with good results. At times egg rafts failed to mature, but if the young larvae could be induced to pass the first or second instar safely, development was assured. With the advent of the unfavourable season of winter no breeding took place in any of the waters for fully three months, but when warmer weather set in *C. fatigans* again laid rafts upon both " phauloteles " and " diffusa " water ; further plant food has also been supplied, and the larvae have since matured normally.

Even under the most ideal conditions a great many larvae fail to mature. For instance, an egg raft laid on 10th May gave rise to 256 larvae, of which 86 failed to reach maturity; ideal laboratory conditions were maintained during the period of growth, and the last of the 86 males and 84 females to hatch out did so exactly seven weeks after the eggs were laid. On another occasion, later in the year, one egg raft produced 259 larvae, of which 82 were females and 46 males; the last of these took two months to reach maturity, whilst the remaining 131 failed to mature at all.

These two instances, selected from a number of cases, are considered sufficient to show that it is quite a common occurrence for a large percentage of the larvae to die from some cause or other, imperfectly understood, and therefore the death of young larvae in the experimental jars appears to be nothing unusual.

N. phauloteles under Laboratory Conditions.

When specimens of this plant were first brought in from the field, it was found to occur in small quantities in pH 6·6 in a side pool of the main Kedron Brook at Enoggera, evidently washed there by recent floods. As soon as *N. phauloteles* had established itself in a glass vessel, egg rafts were laid on this water by *C. fatigans* on two occasions, but the larvae failed to mature. This vessel constantly replenished with tap-water lay exposed for over five months, covering a period of late summer and early winter, without mosquitos taking any further notice of it. During a spell of warmer weather, the plant being at the time in a state of partial decay, *C. fatigans* selected it; soon after the eggs hatched, some dried blood was added to the water, and the young larvae began to make good growth. Eight days afterwards another egg raft was laid. Owing to the large number of larvae, the food-supply being considered insufficient, some leaves of *Valisneria* were added; this food was much appreciated, the larvae made rapid strides and appeared to be perfectly normal, the pH during this period remaining in the region of 8·2. This experiment certainly suggests that food is the primary consideration, for such results as these destroy belief in the toxicity of this plant.

N. diffusa under Laboratory Conditions.

The consistent increase in salts in indoor vessels, due to replenishing, naturally tends to introduce a state of abnormality into our laboratory investigations, which, if overlooked, would lead to erroneous deductions. In order to put this to the test, on 2nd December 1926 specimens of fruiting *Nitella diffusa* were carefully washed in distilled water and divided into two lots; one was placed in a glass jar with tap-water and the other in freshly distilled water reported to be chemically pure. Both these were exposed to the atmosphere of the laboratory and kept side by side throughout the whole period of observation, which lasted for practically nine months, during which time daily records were kept, no extra food other than the plant itself being added.

Experiment I.—*Nitella diffusa and Tap Water, December* 1926 *to August* 1927. Both *C. fatigans* and *Aëdes argenteus* had access to this vessel and entirely ignored it, and during the whole period of time under observation no eggs of either species were laid on this water; but in order to ascertain whether the insects could live in it, larvae of these two mosquitos were introduced at regular intervals, and the great majority pupated and hatched out, showing quite conclusively that though the water was not selected, mosquitos were able to grow and mature, even if, through the scarcity of food, growth was somewhat retarded. The pH remained in the region of 8·0 during the whole period.

Experiment II.—*Nitella diffusa and Distilled Water, January* 1927—*Mid-summer to Mid-winter. A. argenteus* selected this vessel entirely of its own accord, and larvae were first recorded on 24.i.1927.

February.—Three small batches of eggs, totalling about 50 in all, were laid on 7.ii.1927, about 30 on the surface of the water and the remainder in two lots on the dry sides of the vessel at different levels; the sides of the vessel were covered with thick bacterial scum derived from the surface of the water to which reference is made elsewhere. These larvae matured.

March.—Another batch of eggs was laid on 31.iii.27 by *A. argenteus.*

April.—Larvae matured and were observed to hatch out on 7.iv.27.

May.—*C. fatigans* selected this water on 16.v.27, the egg raft hatching out within two days. Larvae were plentiful; *A. argenteus* was observed to be feeding on the stems of the plant—preferring the decaying portions.

June.—Larvae of *C. fatigans* flourished and matured by 25.vi.27.

July.—The last pupa of *A. argenteus* hatched out by 12.vii.27, after which colder weather set in and the water was abandoned. The plant completely decayed and left only a very small amount of a brownish flocculent mass at the bottom of the vessel; no plant food of any kind was recognisable. By 16.vii.27 the pH rose to 7·4, and larvae of *A.* (*Finlaya*) *notoscriptus* (Skuse) were introduced, but although a few of the older larvae hatched out, the greater bulk of them died.

During the whole of this period of growth, the hydrogen-ion concentration of the water remained in the region of neutrality. It is not a little significant that this water should have been selected from among a dozen or more potential breeding-places to which these two mosquitos had equal access.

Both these water samples were examined on 16.iii.27 and gave the following analyses :—

	Nitella plus tap water.	*Nitella plus distilled water.*
	Parts per 100,000.	
Alkalinity	3·7	0·4
Hardness	6·0	1·1
Chlorides	7·4	1·0
Sulphates	5·0	1·868
Sodium	2·54	0·96
Potassium	0·46	0·064
Oxygen consumed (30 min. at 212° F.) ...	0·65	0·95

Nitella and Anophelines.

On several occasions when *Anopheles annulipes* were plentiful they were placed in jars containing species of *Nitella,* but not once did they fail to mature; the same results were obtained when *Chara benthami* was used. Anophelines are evidently true to their liking of algal growth as food.

Cladophora (A.) holsatica, Kütz.

Whilst hunting for specimens of *Nitella* the absence of mosquito larvae in an artificial fountain in a bush-house in the Brisbane Botanical Gardens was considered peculiar. The water was beautifully clear, and at first sight there seemed no reason why *A. argenteus* should not select this water for breeding purposes. A close examination disclosed the presence of a clump of minute algae lying at the bottom of the cement-lined fountain, the high alkalinity of the water (pH 8·6) attracted attention, and a specimen of the alga was secured and ultimately submitted to Professor Fritsch, who identified it as *Cladophora* (*Aegagropila*) *holsatica,* Kütz. It is a species which usually sooner or later forms floating balls, but also grows as cushions. This species has

been under observation in the laboratory from the very first; one lot was placed in an old porcelain filter which had been out of requisition for some time, and the other lot was placed in a glass jar. The algal water in the first vessel remained in the region of pH 8·5, whilst the water in the second remained at about pH 7·6; so that the difference between the two, it seems, can be explained best by the nature of the vessels in which the plant has been kept for considerably over twelve months. It is extraordinary that ever since this plant has been placed in the porcelain vessel *C. fatigans* (and *C. fatigans* alone) has selected it for breeding purposes; egg rafts have been laid at almost regular intervals for the last 15 months, with the exception of the winter months, and yet never has one single larva produced from these eggs ever reached maturity. The case is different, however, with other larvae introduced. On several occasions such have pupated and produced adult mosquitos, but these were entirely confined to larvae in the final instar, and this in the absence of food-stuffs is probably the determining factor. This plant, while growing, is responsible for a most objectionable odour, noticeable sometimes at a distance of 3 to 6 feet. Larvae of *C. fatigans* placed in the glass vessel with *Cladophora* were more easy of observation than those in the opaque jar. They behaved most strangely when placed in the water, and seemed to be decidedly uncomfortable, showing a tendency to drop motionless to the bottom of the jar and to remain there for some time as if dazed; when they did wriggle their way back to the surface, they remained for a long time almost motionless. When removed to fresh water in another vessel they revived after a comparatively short period.

This seeming paralysis of the larvae may be caused by the action of a narcotic poisonous gas, such as CO_2, being emitted from the plant during the process of decay and the fact that incompletely paralysed larvae tend to recover when removed from the irritant seems to suggest that explanation as a feasible one. If this should prove to be the case, it will be worthy of further investigation.

It is a common occurrence for Cladophoraceae when undergoing decay to give rise to rather evil-smelling substances. According to Fritsch there was in the autumn of 1925 a great development of another species, *Aegagropila sauteri*, in the Norfolk Broads, and its growth was accompanied by considerable mortality among the fish. It is difficult to say, however, whether this was due to poisonous action or to asphyxiation owing to excessive use of oxygen by the large bulk of alga at night.

As mosquito larvae get their oxygen directly from the air, it is difficult to see how asphyxiation could be concerned, unless, unknown to us, larvae are partly dependent upon a supply of oxygen from the water and possess some mechanism to enable them to acquire it. On the other hand, the unpleasant smell of a foetid nature may arise when parts of the *Cladophora* decay, and it may be the evil-smelling products of this decay which lead to the discomfort of mosquito larvae.

Analysis of Water growing Cladophora *under Laboratory Conditions.**

	Sample 1 *Nov.* 1926.	*Sample* 2 *Feb.* 1927.
Alkalinity	15·3	18·2
Hardness	10·0	10·4
Chloride	12·4	18·3
Sulphates	Trace	2·072
Sodium	n.d.	5·24
Potassium	n.d.	2·36
Nitrites	Trace	n.d.
Free and saline ammonia	0·006	n.d.
Albuminoid ammonia	0·015	n.d.
Oxygen consumed (30 min. at 212° F.) ...	0·19	0·043

* The analyses of water and Nitellas were kindly made by Mr. W. J. Chamberlain, Water Chemist, M.W.S. & S.B., to whom my best thanks are due.

The difference in these is probably due to the fact that the water in the jar was constantly replenished with tap-water, and evaporation would gradually lead to a higher concentration every time fresh water was added.

Experiment to test the Effects of Decay upon the Water and Mosquito Larvae.

But in order to ascertain if any decay were going on, at the suggestion of Professor Fritsch, a little of the alga (killed by immersion in boiling water) was allowed to decay, and the effect of the filtered liquid was tried on the larvae.

Whilst this experiment was in progress it was also thought advisable to try the same with other reputed larvicides. An infusion of each of the four different algae was made on 7th August and allowed to stand for exactly three weeks ; a disagreeable smell was particularly noticeable with *Cladophora* and *Spirogyra*. No food of any kind found its way into the test-tubes, which were all protected with plugs of cotton-wool. One *Aëdes argenteus* (all that was available at the time) and three *C. fatigans* larvae used in each case, and in order to avoid any possibility of error on this score they were all, as nearly as possible, of the same age.

Time.	*Cladophora holsatica.*	*Spirogyra nitida.*	*N. diffusa.*	*N. phauloteles.*
Sept. 6, 9 a.m.	Filtered and mosquito larvae added.			
7	Slightly abnormal	All well	All well	1 *fatigans* pupated
8	Keep to the bottom.	1 *fatigans* pupated but dead.	All well	All well
9	All larvae alive but keep to the bottom.	Normal.	1 *fatigans* and 1 *argenteus* pupated.	Remainder of *fatigans* pupated.
10	,,	1 *fatigans* pupated	Remainder pupated.	All well
11	,,	Normal	In pupal state ; normal.	Normal
12	,,	Remainder pupated.	1st pupa hatched	3 *fatigans* hatched out.
13	,,	All well	Remainder hatched out.	*A. argenteus* larva well.
14	No change	1 *fatigans* hatched out.	—	,,
15	Larvae appear more lively.	Normal	—	,,
16	No change	Normal	—	,,
17	No change	Normal	—	,,
21	All *fatigans* larvae dead.	*A. argenteus* hatched out.	—	—
21	*A. argenteus* pupated but died in the attempt.	—	—	Still alive on the 29th, when the experiment was abandoned.

This experiment is of value, as it is evident that only in one instance, namely, in the case of *Cladophora*, did the infusion show any signs of inhibiting larval growth. Here we certainly have something abnormal ; although the *C. fatigans* larvae lived for 14 days in this infusion and may have died of starvation, it is significant that they made no attempt to pupate, whilst *A. argenteus* died immediately after pupation.

Further experiments along these lines will be conducted as opportunities present themselves.

Hydrogen Ion Concentration.

One of the first observations made when these investigations were commenced was to the effect that the water of *Nitella*-containing vessels showed a distinct tendency to become alkaline and remain in the region of pH 8·5 ; and the very natural deduction was made that this was due to the influence of the plant in question.

Numerous experiments made upon waters transferred to the laboratory throw a very different light upon the subject. A number of test-tubes were filled with water each of a different acidity, and the pH of each demonstrated by means of an indicator. After standing in the laboratory for some time, the acidity slowly disappears in every case and sometimes reaches a considerable state of alkalinity. This may be due to a dual agency, bacteria on the one hand and CO_2 on the other, but the question is of sufficient importance to justify further enquiry ; the fact nevertheless remains that if this possibility is overlooked, erroneous deductions are bound to result, and hence one is naturally dubious about the actual value of laboratory findings with regard to hydrogen-ion concentration.

Scums.

All waters in which aquatic plants are kept in the laboratory develop and maintain scum.* This scum has been attributed with deterrent qualities, and Buhot[3] makes the remarkable statement, referring to a second kind of film on the same water, that it has the power of " preventing the female mosquito from laying her eggs upon the surface of any creek, pool, tank or receptacle where this plant should be growing." To say the least of it, the statement is incorrect, for not only does *C. fatigans* lay its eggs upon such scums, but the young larvae prefer to linger near and feed upon the bacteria, definitely avoiding that portion of the water where scums do not exist. Such scums are primarily bacterial, the principal organism involved being *B. subtilis*. In Sample 9, where *N. diffusa* was kept in distilled water, no motile organisms were present. No pronounced change was observed in the pH value of the neutral medium inoculated from nine samples submitted for examination to Mr. C. J. Pound, Government Bacteriologist ; the following readings were taken 48 hours after inoculation and incubation :—

	pH.
Control tube (not inoculated)	7·0
Sample 1—grown on *Nitella diffusa*	8·5–9·0
,, 2— ,, ,, ,, ,, ...	8·5–9·0
,, 3— ,, ,, *Cladophora holsatica*	8·5–9·0
,, 4—*N. diffusa*	8·0
,, 5—grown on *N. phauloteles* decomposing	8·0
,, 6—*N. phauloteles*	8·5
,, 7—*N. phauloteles* mostly decomposed	7·5
,, 8—*N. diffusa* in tap-water	8·5
,, 9—*N. diffusa* in distilled water	7·5

From these results, so kindly obtained by Mr. S. Thorn, Assistant Bacteriologist, to whom my best thanks are due, it would appear that these bacteria have a tendency to produce a slight alkalinity ; and this is important in view of the observation made that all waters standing in a laboratory exposed to dust, etc., possess this same tendency of becoming alkaline, however acid they may have been in the first place.

Abnormal Movements of Larvae.

It has been repeatedly noticed in the laboratory that larvae display unusual movements, either revolving on their axes or periodically biting at their breathing syphons,

* For the identification of various scum bacteria and other kind assistance I am indebted to Dr. J. V. Duhig, Director, Pathological Dept., Brisbane Hospitals.

as larvae do when poisoned by oil. This abnormality has been observed more frequently in vessels where the surface of the water is covered with a bacterial scum, irrespective of the presence of plant life. The occurrence is common, and the larvae mature in spite of it, but whether the causative agent may be due to some mechanical obstruction or to the influence of the bacteria has not been determined. There is the possibility that the continual motion of the terminal flagellae of the motile *Spirilla*, extremely common in decaying vegetable matter, may affect the sensitive larval hair-tufts to such an extent as to make the larvae intensely uncomfortable and may, in consequence, produce such gyrations as referred to.

Summary.

(1) An effort has been made to find an explanation for certain problems involved in the selection of breeding-places of mosquitos in Queensland.

(2) Many of these problems must remain unsolved until it is possible by patient study of local conditions to bring all the factors involved into play.

(3) In order to explain the reason for the avoidance of natural water, where it exists, it is suggested that the soils that underlie them should first be taken into consideration, and that the waters should be examined with reference to their physical and chemical conditions.

(4) Observations and experiments, spread over a period of eighteen months, confirm the findings of previous authors that Characeae do not in themselves possess larvicidal properties.

(5) That food is the main determining factor in the choice of preferential breeding-places seems to be borne out by actual results obtained, and that when such are not available, mosquitos will resort to breeding-places of compulsion, such places being usually observed to be entirely or partly devoid of food supplies.

(6) It is suggested that the salts of alumina and iron in the ferrous state tend to destroy food organisms, and that where these conditions exist, the water is not selected preferentially.

(7) The presence of algae leads to the appearance of *Anopheles annulipes*.

(8) That *Cladophora holsatica* inhibits larval growth seems to be experimentally established.

(9) Bacterial scums are mainly due to *B. subtilis* and have a tendency to produce a slight alkalinity.

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ON THREE BRACONID PARASITES OF THE GELECHIID MOTH, *PLATYEDRA EREBODOXA*, MEYR.

By D. S. Wilkinson,
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Microbracon hancocki, sp. n.

♂♀. Black; the front legs completely, the middle legs except the coxae, hind trochantines, hind femora, basal third of hind tibiae, mouth-parts largely, all ventrites, the lateral membranous margins of the 1st tergite, about each lateral quarter of the 2nd and succeeding tergites, bright red testaceous.

Colour variable, the hind femora more or less strongly, occasionally even the middle femora, the middle tibiae and tarsi somewhat, tending sometimes to be nigrescent; 1st tergite occasionally red to testaceous laterally, and the red testaceous border of the succeeding tergites variable in extent, on the 2nd tergite in one specimen occupying on each side fully three-eighths of the breadth of the tergite; the stigma and wing veins not always deep black.

♀. *Head*: face and frons strongly, vertex and all orbits more or less, coriaceous; occiput more or less entirely smooth; ocelli in a distinct, smooth tubercle, close together, the posterior pair very obviously nearer to one another than to the eye; flagellum with 25, 28, 28 and 29 joints, and in one specimen one flagellum with 22 and the other with 23 joints; apical joint of the flagellum with an extremely short

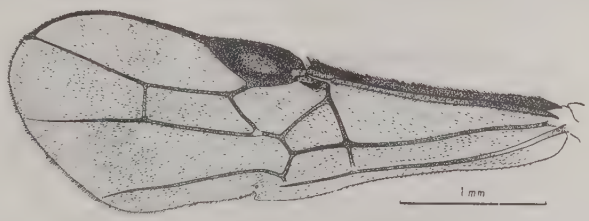

Fig. 1. *Microbracon hancocki*, sp. n., ♀, forewing.

and hardly discernible apical style. *Thorax*: mesonotum smooth, polished, and shining, except for some weak, rather indefinite, sparse punctuation which occurs chiefly in the region of the notauli, and posteriorly; notauli shallow but definitely present, particularly anteriorly, converging posteriorly but meeting neither one another nor the scutellar depression save possibly as an extremely shallow, broad, general depression; scutellar depression crenulate; disc of scutellum extremely finely, sparsely but regularly, punctate; propodeon with some extremely weak and sparse punctuation, medianly at extreme apex with a short strong carina, along apical margin more or less crenulate, sometimes with a very broad and shallow median longitudinal excavation, otherwise smooth and shining, except that there are strong indications that the integument tends towards a coriaceous condition. *Wings* (fig. 1) with a fenestra at the junction of the 1st transverse cubital with the cubital; 2nd transverse cubital in length averaging two-fifths the 2nd abscissa of the radial. *Abdomen* about as broad as the combined lengths of the 2nd, 3rd, 4th, and 5th tergites; 1st tergite roughly square, except that it narrows sharply to the base, with the impressed lines described for *M. kirkpatricki*, Wilkn., more strongly marked; 2nd and all succeeding tergites more or less coriaceous, always with fine longitudinal striae

except the apical tergites; 2nd tergite lightly rugose, with a comparatively well marked, more or less smooth, middle field; 2nd suture strongly bisinuate but not so strongly as in *M. kirkpatricki*, somewhat crenulate in some specimens; ovipositor sheaths from 2·0 to 2·5 mm. in length, averaging about 2·2 mm., about 1·4 times as long as the abdomen.

♂. Agrees with the description of the female except that the flagellar joints are 24, 16, 26, 26, 26, and 27.

Length, ♀♀, 2·75–3·5 mm., ♂♂, 2·5–3·0 mm.

UGANDA: Kampala, 5 ♀♀, 6 ♂♂, 14.ii.1926 (type), 17.ii.1926, ii.1926 (*G. L. R. Hancock*).

Type deposited in the British Museum.

Much like *M. lefroyi*, D. & G., but differing from that species, *inter alia*, in the shape of the 2nd cubital cell.

Chelonella ritchiei, sp. n.

♀♂. Black; legs except hind coxae, the costal, basal, and 1st abscissa of the medial veins, the basal half of the 1st abscissa of the anal vein, red testaceous; stigma black, other wing veins darkish brown; scape red; flagellum normally black, but sometimes decidedly reddish basally; tegulae dark reddish brown; the apical third of the hind tibiae, the hind femora in apical half, the apical joints of the hind tarsi, more or less nigrescent; basal third of the carapace pale.

♀♂. *Head* finely and closely rugosely striate more or less throughout; clypeus definitely smoother; facial depressions further from one another than from the

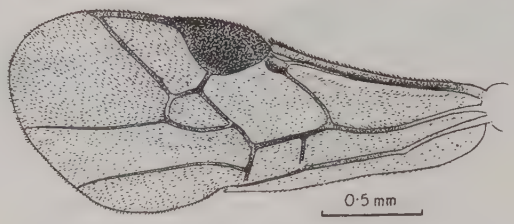

Fig. 2. *Chelonella ritchiei*, sp. n., ♂, forewing.

eyes, and further from the eyes than from the apex of the clypeus; ocelli not on a raised or otherwise differentiated tubercle, the distance between the posterior pair greater than the breadth of one ocellus, but less than the distance between the ocelli and the eyes; flagellum in the ♀ with 14 joints, in the ♂ with 19–20 joints; in the ♀ the antennae are about as long as the head and thorax together, in the ♂ much longer. *Thorax* largely with broad strongly marked reticulations; the notauli strongly marked as broad crenulate furrows, the parapsides being largely weakly punctate and with only a few weak reticulations; the median posterior area between the notauli is broadly reticulate, from which area there runs anteriorly a double line of rather weaker reticulations; the scutellar depression broad and strongly crenulate disc of scutellum finely punctate, except around the margins where it is weakly reticulate; lateral faces of the scutellum strongly reticulate, save for a broad, completely smooth, highly polished, shining, transverse band across the apices, these bands not meeting round the apex of the scutellum; metanotum and propodeon strongly reticulate, the latter with four tooth-like prominences, one on each side and a pair rather close together medianly, the median pair more or less obsolete in

the female ; joining these teeth is a strong ridge beyond which the propodeon is very strongly declivous. *Wings* (fig. 2) with the 1st abscissa of the radial definitely straight. *Legs* with the hind coxae on outer faces weakly transversely striate. *Abdomen* : carapace more or less throughout with strong, rather irregular, longitudinal striae, which are joined at uneven intervals by considerably weaker, transverse striae ; male genital opening in the carapace small and not linear.

Length, 3 mm.

UGANDA : Kampala, 1 ♀ (type), 3 ♂♂, 10.iv.1926 (*G. L. R. Hancock*), and 1 ♂ unlabelled. TANGANYIKA TERRITORY : Morogoro, 2 ♂♂, xi.1922 (*A. H. Ritchie*).

Type deposited in the British Museum.

Extremely like *Chelonella curvimaculata*, Cam., but immediately separated from that species by the shape of the male genital opening, which, a small round hole, is describable almost as punctiform, as against that of *curvimaculata*, which is strongly transverse, extending round from the apex on each side of the carapace up towards the base of the abdomen for a distance almost one third the length of the carapace ; also the 1st abscissa of the radial in *curvimaculata* is definitely sinuate.

I present below a key ; but since there are species both in *Chelonus* and in *Chelonella* that have been described from only one sex, I have included in the key all the known Ethiopian forms of both these genera. I was also constrained to combine these in one key since I am not satisfied that *Chelonella* will stand, despite the fact that I have described my species under this genus.

Cameron's species, *Chelonus robertianus*, the type and a long series of which are in the British Museum, is referable to *Chelonella*, if we are to accept Szépligeti's genus. *Chelonella curvimaculata*, Cam., the type and a long series of which are also in the British Museum, was rightly transferred by Brues from *Chelonus*.

Key to the Ethiopian species of Chelonus *and* Chelonella.

1. Abdomen basally without light markings 2
   Abdomen basally with light markings 4
2. Length 6 mm. ; ♀ with 25-jointed antennae ... ... *capensis*, Cam.
   Length 2 mm. ; ♀ with 16-jointed antennae ... ... *robertiana*, Cam.
   Length 4·5 mm. 3
3. Described from ♀ only ; antennae black and 16-jointed ; all legs black *nigricornis*, Szép.
   Described from ♂ only ; antennae red and 20-jointed ; fore legs almost completely yellow-red, remaining legs not all completely black *ruficornis*, Szép.
4. A light marking at base of abdomen on, or towards, each side 5
   Light marking stretching completely across base of abdomen, or one large marking medianly 9
5. First abscissa of the radial almost as long as the 1st transverse cubital, the 2nd abscissa of the radial shorter ; ♀ with 27–jointed antennae *bifoveolatus*, Szép.
   Venation not so describable, the 1st and 2nd abscissae of the radial equal in length, shorter than the transverse cubital 6
6. Stigma and nervures black ; hind tibiae (except the apices) and hind tarsi white ; antennae with 27 joints ... ... *pilosulus*, Szép.
   Not so describable 7
7. Abdomen elongate, longer than head and thorax together, viewed from above three times as long as broad, the lateral margins parallel *vaalensis*, Cam.
   Abdomen viewed from above not twice as long as broad... 8

8. Mesopleural sulcus irregularly and roughly reticulate ... *erythropus*, Cam.
   Mesopleural sulcus very much smoother and not so deep, the reticulations enclosing well defined, evenly shallow depressions ... *tettensis*, Gerst.
9. Wing veins black ; base and middle of abdomen striate ; 1st and 2nd abscissae of radial thicker than the 3rd ; densely covered with white pile *rufoscapus*, Cam.
   Wing veins dark brown ; abdomen more or less wholly striate ; 1st and 2nd abscissae of radial not thicker than the 3rd ; not describable as densely covered with white pile 10
10. First abscissa of radial slightly but definitely sinuate *curvimaculata*, Cam.
    First abscissa of radial definitely not sinuate ... ... *ritchiei*, sp. n.

Apanteles diparopsidis, Lyle.

Apanteles diparopsidis, Lyle, Bull. Ent. Res., xvii, 1927, p. 415.

Uganda: Kampala, 2 ♀♀, 1 ♂, 2.iv.1926 (*G. L. R. Hancock*).

A species originally described from the Transvaal and as parasitic on the red boll-worm, the Noctuid, *Diparopsis castanea*, Hmps.

Certain minute differences are noticeable between this series and the type series of *diparopsidis* ; in the absence of a reasonable number of specimens in either series, however, I am unable to decide what importance, if any, should be attached to these differences ; I am strongly inclined to think none.

The above three species were all bred by Mr. Hancock from the Gelechiid, *Platyedra erebodoxa*, Meyr., and this association is further complicated by the occurrence also of two other species of Parasitic Hymenoptera, a Chalcid and a Proctotrupid, which are presumably hyperparasites ; these have been identified by Dr. Ferrière, the former as a species of *Eurytoma*, and the latter as a species probably belonging to the Calliceratine genus *Calliceras*, Nees (*Ceraphron*, Jurine).

In some notes that he forwarded at the time that he sent the parasites for identification Mr. Hancock goes on to say that *P. erebodoxa* occurs in Uganda in areas north and north-west of Lake Victoria, and that it probably follows the distribution of its host-plant, *Hibiscus diversifolius*. He says further that the larvae of this moth may be found at all times of the year in the seed-heads of this plant, and that though parasitised in varying degrees the insect is never rare. Mr. Hancock continues : " It has been possible to piece together most of the life-history of *Microbracon hancocki*, but no observations have been made on the other species. Oviposition has never been observed in captivity, but one batch of eggs was found in a freshly gathered capsule, though none have been found in material examined the day after the capsules had been brought to the laboratory ; but very young larvae are not uncommon. I therefore conclude that the incubation period is probably not more than 48 hours. No specimens of female parasites have been captured in the field, though one parasite was observed about 3 p.m. flying round some seed-capsules containing larvae and parasites, unfortunately, however, escaping, so that an accurate identification could not be made.

" The number of larvae found on each host varies from two to five, and it is probable that the eggs are laid in batches of perhaps three to five. The single batch of five was found loosely laid beside the larva in the capsule near the posterior end of the host. Two of these parasitic larvae were preserved, and one measured 1 × 0·2 mm. They are of a transparent white colour.

" The remaining larvae emerged the next day, and from their behaviour and from that of other very young larvae, the larval stage may be said to last from four to five days, at the end of which time the cocoon is spun, pupation taking place one to two days later.

" The full-grown larva, owing to the colour of its internal organs, is pinkish, and this colour agrees closely with the markings on the host larvae. Very young parasitic larvae may easily be overlooked, being mistaken for part of the colour pattern of the host. The larvae vary considerably in size, their length being 3–5 mm., and their maximum breadth 1·0–1·5 mm.

" The cocoons are spun together at the base of the capsule, but occasionally they may be found singly. The shape of these tough, semi-transparent, whitish cocoons depends on the external pressure ; two or three cocoons are usually spun together forming a wad at the bottom of the capsule. In all observed cases the adult emerged from the cocoon after ten days.

" The maximum life of a female in the laboratory was twelve days, the minimum, five. In the former case the female was provided with sugar-water and was unfertilized, in the latter no food was given and a male was present. The life of the males varied from two to nine days, the longer when there were no females in the same box, the shorter in the presence of a female.

" When larvae were taken from their host and transferred to another they died, being entangled in the silk spun by the host and never obtaining a hold on the larva. It is possible, therefore, that, as in the case of *Microbracon mellitor*, Say, the female Braconid paralyses the host before oviposition. *Microbracon kirkpatricki*, Wilkn., a valuable parasite of *Platyedra gossypiella* in Kenya (Bull. Ent. Res., xviii, p. 47) appears to be an internal parasite."

OBSERVATIONS ON THE THERMAL DEATH POINTS OF THE BLOW-FLY AT DIFFERENT RELATIVE HUMIDITIES.

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When Dr. W. D. Pierce published his paper on the relationship of temperature and humidity to insect development, a new field for research in Medical Entomology presented itself. A complete knowledge of the effects of these factors on insect life would be of great value, not only in the determination of seasonal incidence, but also as an important step forward towards natural control, and towards the solution of many other practical problems. On the suggestion of Dr. P. A. Buxton, who has already shown how such data can be applied in practice (1923), I undertook the following investigation.

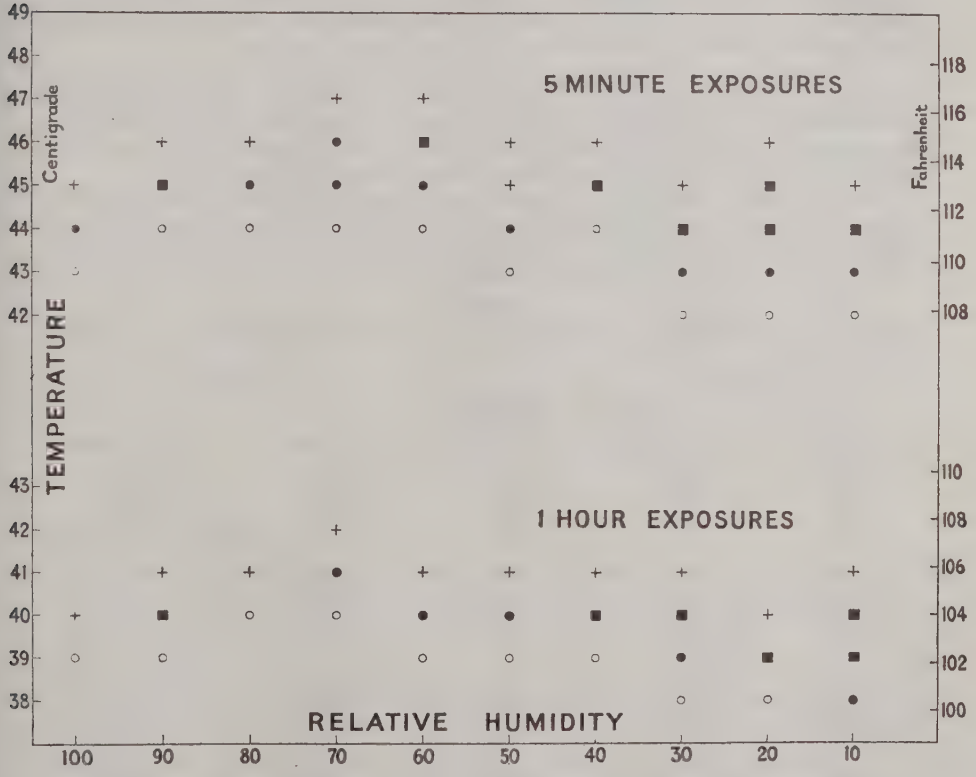

Fig. 1. Graph showing effects of exposing *Calliphora* to various temperatures and humidities for five minutes and for one hour.

A cross = 100 per cent. mortality, a black square = over 50 per cent., a black dot = under 50 per cent., a ring = no mortality.

I have chosen the blow-fly, *Calliphora erythrocephala*, Mg., because the culture can be very easily kept going throughout the year; also if the culture fails, this fly is easily procurable at any time.

The experiments consisted of exposing the flies (i) for five minutes, (ii) for one hour, to temperatures ranging from 30° C. to 50° C. in rises of 1° and at the same time to relative humidities from 0 per cent. to 100 per cent. in 10 per cent. rises. Every combination of temperature and humidity within these limits was tested.

Five Minute Exposures.

The apparatus consisted of a two-necked Woulff bottle immersed up to the necks in a water-bath. Mixtures of sulphuric acid and water at the bottom of the flask gave the desired humidity. The temperature and humidity were taken during each experiment by means of wet and dry bulb thermometers. Air movement was set up by pressure on a bulb attached to a piece of glass tubing in the neck of the flask. As it was desirable to expose the flies directly to the atmosphere, they were etherised and tied on to the end of a long piece of wire. When recovered, they were placed in the atmosphere for 5 minutes. At the end of that time they were removed to laboratory air, and the result noted. If there was any visible movement the fly was recorded as being alive; if none, or if only slight movement of the proboscis, as inert. The flies were then left for 24 hours and the result again recorded.

The results of these experiments proved very interesting. They are recorded in Table I, and graphed in fig. 1, in terms of temperature and relative humidity. From these data it would appear that the *Calliphora* were able to withstand higher temperatures at relative humidities from 60 per cent. to 80 per cent. with an actual optimum at 70 per cent. These results were confirmed by repetition.

It is not possible, however, with such short exposures to delimit accurately the range of temperature and humidity which is unfavourable to the flies under natural conditions. For this reason it was decided to continue the experiments but to expose the flies to the same range of conditions for periods of one hour.

TABLE I.

Effects of exposing Calliphora *to various Temperatures and Relative Humidities for Five Minutes.*

Temperature.		Relative Humidity. per cent.	Results.	
Dry bulb. ° C.	Wet bulb. ° C.		Immediate.	After 24 hours.
43	43	100	12 alive	12 alive
44	44	100	12 inert	10 alive
45	45	100	12 inert	none alive
46	46	100	12 inert	none alive
43	41·5	90	12 alive	12 alive
44	42·5	90	12 alive	12 alive
45	43·5	90	12 inert	1 alive
46	44·5	90	12 inert	none alive
43	39·5	80	12 alive	12 alive
44	40·5	80	12 alive	12 alive
45	41·5	80	4 alive	9 alive
46	42·5	80	12 inert	none alive
43	37·5	70	12 alive	12 alive
44	38·5	70	12 alive	12 alive
45	39·5	70	12 inert	10 alive
46	40·5	70	2 alive	8 alive
47	41·25	70	12 inert	none alive

TABLE I (*contd.*).

Effects of exposing Calliphora *to various Temperatures and Relative Humidities for Five Minutes.*

Temperature.		Relative Humidity. Per cent.	Results.	
Dry bulb. ° C.	Wet bulb. ° C.		Immediate.	After 24 hours.
43	35·5	60	12 alive	12 alive
44	36·5	60	12 alive	12 alive
45	37·5	60	9 alive	10 alive
46	38·25	60	1 alive	1 alive
47	39	60	12 inert	none alive
43	33	50	12 alive	12 alive
44	34	50	9 alive	9 alive
45	35	50	1 alive	none alive
46	35·5	50	12 inert	none alive
43	31	40	12 alive	12 alive
44	31·5	40	5 alive	12 alive
45	32·5	40	12 inert	2 alive
46	33	40	12 inert	none alive
42	27	30	12 alive	12 alive
43	28	30	8 alive	9 alive
44	29	30	12 inert	3 alive
45	29·5	30	12 inert	none alive
42	24·25	20	12 alive	12 alive
43	25	20	10 alive	9 alive
44	25·5	20	7 alive	3 alive
45	26	20	12 inert	2 alive
46	26·5	20	12 inert	none alive
42	21	10	10 alive	12 alive
43	21·5	10	4 alive	10 alive
44	22·1	10	4 alive	2 alive
45	22·5	10	2 alive	none alive
46	23	10	12 inert	none alive
42	19	5	12 alive	12 alive
43	20·5	5	9 alive	11 alive
44	22	5	4 alive	2 alive
45	22·5	5	12 inert	none alive

One Hour Exposures.

Several changes were made in the technique of these experiments in order to do away with some of the disadvantages of the former one. Two things were desirable, (i) to expose the flies to the atmosphere without etherisation ; (ii) to devise a method whereby a continuous gentle current of air could be maintained

The apparatus finally decided upon consisted of one large three-necked Woulff bottle, to which were attached three or four smaller ones in series; all were immersed in the water bath as before (fig. 2). The smaller bottles contained the necessary mixture of sulphuric acid and water. Air was drawn through all of these and then through the larger bottle by the pressure pump attached to the water-tap. Thus the necessary atmosphere was created in the larger bottle, and the flies could be placed in it and allowed to fly about. When actually placing the flies in the larger bottle, it is desirable to do so in such a manner that no drop in the temperature will result. If the flies are collected in a long wide glass tube, both ends of which are

closed with cotton-wool, this can easily be done. The stopper of one of the necks of the Woulff bottle is removed and the tube with flies quickly applied to the opening. The lower piece of cotton-wool is then pulled away, and the flies pushed down into the bottle. The tube is then removed and the stopper replaced. I have found that no drop in temperature resulted when this was done.

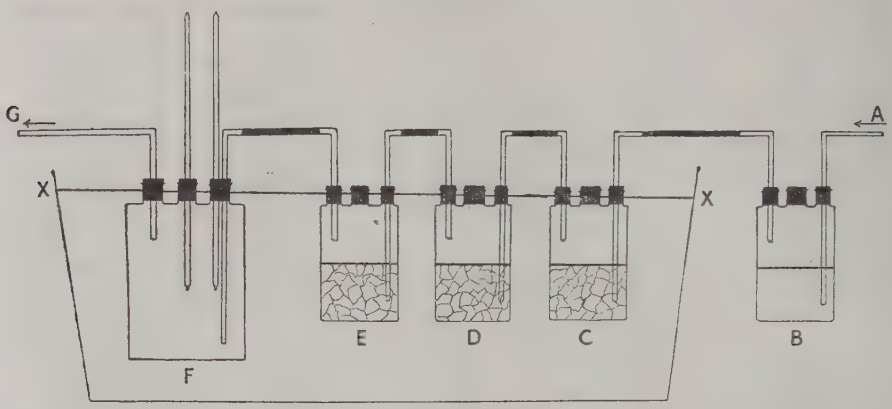

Fig. 2. Apparatus used in experiments with one hour exposures. Air entering at A was drawn through bottles B, C, D, E (all containing mixtures of sulphuric acid and water) into bottle F ; B also serves as an observation point for the passage of the air-current ; G leads to the pressure pump ; xx=water level in water-bath.

The results of these experiments, recorded in Table II and graphed in fig. 1, showed that the thermal death point was a few degrees lower than with the five-minute exposures, but the curve obtained was very similar. There still appeared to be an optimum at 70 per cent. relative humidity, and saturated or dry air was fatal at a lower temperature.

TABLE II.

Effects of exposing Calliphora *to various Temperatures and Relative Humidities for One Hour.*

Temperature.		Relative Humidity. Per cent.	Results.	
Dry bulb. ° C.	Wet bulb. ° C.		Immediate.	After 24 hours.
38	38	100	12 alive	12 alive
39	39	100	12 alive	12 alive
40	40	100	12 inert	none alive
41	41	100	12 inert	none alive
38	36·5	90	12 alive	12 alive
39	37·5	90	12 alive	12 alive
40	38·5	90	12 alive	2 alive
41	39·5	90	12 inert	none alive
39	35·5	80	12 alive	12 alive
40	36·5	80	12 alive	12 alive
41	37·5	80	9 alive	none alive
42	38·5	80	12 inert	none alive

TABLE II (*contd.*).

Effects of exposing Calliphora *to various Temperatures and Relative Humidities for One Hour.*

Temperature.		Relative Humidity. Per Cent.	Results.	
Dry Bulb. ° C.	Wet Bulb. ° C.		Immediate.	After 24 hours.
40	35	70	12 alive	12 alive
41	36	70	12 alive	10 alive
42	37	70	4 alive	none alive
43	38	70	12 inert	none alive
39	32	60	12 alive	12 alive
40	32·5	60	8 alive	10 alive
41	33·5	60	12 inert	none alive
42	34·5	60	12 inert	none alive
39	30	50	12 alive	12 alive
40	31	50	6 alive	7 alive
41	31·5	50	12 inert	none alive
42	32·5	50	12 inert	none alive
39	28	40	12 alive	12 alive
40	28·5	40	2 alive	2 alive
41	29	40	12 inert	none alive
42	30	40	12 inert	none alive
38	24·5	30	12 alive	12 alive
39	25·5	30	8 alive	11 alive
40	26	30	4 alive	1 alive
41	26·5	30	3 alive	none alive
42	27	30	12 inert	none alive
38	22·5	20	12 alive	12 alive
39	23	20	4 alive	5 alive
40	23·5	20	12 inert	none alive
41	24	20	12 inert	none alive
38	20	10	5 alive	9 alive
39	21	10	3 alive	4 alive
40	21·5	10	2 alive	1 alive
41	22·5	10	12 inert	none alive

Discussion.

It has been suggested by more than one writer that there are definite boundaries of temperature and humidity which limit the metabolism and activity of insects. Wardle & Buckle have referred to it. Bachmetjev has suggested that there is for each insect a degree of atmospheric humidity which, being most favourable to the maximum rate of metabolism, may be termed the optimum. Regarding this point of optimum humidity one can only theorise. Headlee in his paper on the influence of atmospheric humidity on insect metabolism attached great importance to what he terms a "water optimum"—the amount of body fluid which permits the maximum metabolic reaction. He suggested that the relationship of the insect to humidity depended on whether the body fluid was above this optimum or below.

It is quite comprehensible that in saturated air insects die at a lower temperature because they are unable to regulate their heat by evaporation; but whether dry air is fatal at lower temperatures because of exhaustion of water supply is disputable. With a view to obtaining further information regarding any loss of water by the insect, a number of weighings were done during the experiments with exposures of one hour. These are recorded in Table III.

TABLE III.

Record of Weighings of Calliphora *after One Hour Exposures to (i) the Temperature which was fatal, (ii) a Temperature 1° below at various Humidities.*

Temperature.		Condition.	Weight of 12 flies. gms.	Loss of weight. Per cent.
Dry bulb. ° C.	Wet bulb. ° C.			
39	39	12 alive	0·79	nil
40	40	none alive	0·98	nil
39	37·5	12 alive	0·92	nil
40	38·5	2 alive	0·71	nil
40	36·5	12 alive	0·78	2·3
41	37·5	none alive	0·84	4·8
41	36	10 alive	0·83	8·4
42	37	none alive	0·85	17·1
41	36	12 alive	0·84	5·3
42	37	2 alive	1·02	12·5
40	32·5	10 alive	1·17	3·4
41	33·5	none alive	1·15	7·8
40	31	7 alive	1·02	2·9
41	31·5	none alive	0·98	8·2
40	31	12 alive	0·92	7·6
41	31·5	2 alive	0·83	13·2
39	28	12 alive	1·17	1·7
40	28·5	2 alive	1·12	6·3
39	25·5	11 alive	1·02	4·9
40	26·5	1 alive	1·19	11·8
38	22·5	12 alive	1·14	1·8
39	23	5 alive	1·2	5·8
38	22·5	10 alive	0·81	6·1
39	23	3 alive	0·78	12·1
38	20	9 alive	0·84	8·3
39	21	4 alive	0·85	11·8
Weighing of a group of 36 flies at relative humidity of 50 per cent. :—				
40	32·5	30 alive	2·83	3·2
41	33·5	4 alive	2·79	11·5

The flies were weighed in groups of twelve. It will be seen that in saturated air and at 90 per cent. relative humidity there was no loss of weight. A distinct loss was recorded at all other humidities; this, however, was no greater in dry air than in air at 70 per cent. humidity, which was found to be the optimum. At the temperature that was fatal the loss was consistently greater than that at a temperature 1 per cent. below. The facts in this table bear out the theory that the flies die in saturated air because they are unable to control their heat by evaporation; but the data do not explain death in dry air.

Summary.

In summarising, the following points are to be noted :—

1. The thermal death point of the blow-fly was definitely influenced by the factor of humidity.

2. Saturated and dry air had the effect of lowering the thermal death point.

3. Relative humidities from 60 per cent. to 80 per cent. were more favourable, while relative humidity of 70 per cent. actually was found to be an optimum point.

4. From the weighings it may be concluded that death in saturated air was due to the inability of the flies to regulate their heat by evaporation.

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DYSDERCUS SIDAE, MONTR., IN QUEENSLAND.

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and
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Personal Assistant.

(Plate XIX.)

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1. Introduction.

Like other species of its genus in different parts of the cotton-growing areas of the world, *Dysdercus sidae* is a serious pest of cotton, not as has been stated* from staining the lint by its excrement or being crushed in the gins, but from being the agent by which internal boll-rot fungi enter the green cotton boll.

Such mention as is made of this species in papers dealing with Australian insects† gives the impression that it does not do very much damage. This is probably due to the fact that when the papers were written cotton-growing was in its infancy. It has recently been demonstrated ‡that *D. sidae* and *Tectocoris lineola*, F., are the chief insects that cause internal boll-rots and stained cotton.

Of the last four cotton seasons (1923–1927)only one has been of a nature favourable to cotton. This was the season 1924–25. The others either began well, as in the case of the 1925–26 season, and ended in drought, or began in drought and ended in excessive rain. In the 1924–25 season alone was *Dysdercus* in the fields early. At a place in the southern part of the cotton belt it was seen on ratoon cotton in November and had been there some time, since nymphs were found as well as adults. The writer did not see the beginning of the 1923–24 season, when most of the cotton was planted late, but *Dysdercus* was plentiful late in that season, though not very abundant in the middle.

In 1926 when the season came to an abrupt end, stainers were late in arriving, and in consequence, much of the early cotton pickings were of high grade. In the present season (1926–27) mid-February was the earliest record received, and in some places invasion did not take place until March.

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* J. L. Froggatt, Q'land Agric. Jl., xxi, p. 123. W. B. Gurney, Agric. Gaz. N.S.W., xxxv, pt. 2, Feb. 1924.

† E. P. Mumford, "Cotton stainers and certain other sap-feeding insect pests of the cotton plant."—Emp. Cotton Growing Corp., London, 1925. W. W. Froggatt, 'Insects of the Kurrajong."—Agric. Gaz. N.S.W., March 1905. W. W. Froggatt, "Notes on Australian Hemiptera."—Agric. Gaz. N.S.W., Dec. 1901.

‡ E. Ballard & F. G. Holdaway, "The life-history of *Tectocoris lineola*."—Bull. Ent. Res., xvi, pt. 4, March 1926. E. Ballard, "Some of the causes of low grade cotton."—Q'land Agric. Jl., June 1925. E. Ballard, "Damage done to cotton seed by plant bugs."—Q'land Agric. Jl., Aug. 1925.

From these data it will be seen that the time of arrival in the fields cannot be fixed, nor does it depend apparently on the condition of the cotton. It is more likely to be connected with the fruiting of wild food-plants, drought, or excessive rain. Drought would hold back migrants by denying them the seeds so necessary to their existence ; long-continued rain would inhibit flight and excessive rain would drown eggs and young nymphs ; and perhaps the flooded creek-beds would drown those living on weeds in such situations. Again a late spring would inhibit rapid reproduction, and excessive heat would raise soil temperatures above the thermal death point for the eggs.

In a fairly favourable cotton season green bolls developing from January onwards are certain to give cotton with a higher percentage of stain as the season advances, until some 80 per cent. of the top crop will be rendered practically worthless.

From what is known of the effect of climate on it, a good cotton season should be a favourable one for *Dysdercus*. At present few farmers appear to be alive to the damage which this insect causes, and so long as bushes are heavily laden with cotton and bolls, they do not worry about stain until the results of the grading of their cotton is known.

This paper is the result of field and laboratory work carried out in two consecutive cotton seasons. It leaves many points in connection with the bionomics of *D. sidae* unanswered, but it was decided to publish the results obtained up to the end of the 1927 cotton season, as the senior author's term of service in Australia ended at that time.

The chief mystery is connected with the winter and spring months before migration begins. To probe it satisfactorily a study of the life-histories of the insect's food-plants in the " bush " will have to be made. About some of the chief of these, the Brachychitons,* very little information exists, yet they undoubtedly play a most important part in the general economy of the species.

There are persistent reports of hibernation by *Dysdercus* under logs and in buildings, yet in the authors' experience this has never happened. In different years bugs have been seen feeding and (on the coast) breeding at all times during the cold weather, and the search of suitable shelters where they would be likely to congregate has revealed nothing. It is possible that groups of adults and fifth instar individuals might collect together during a period of extreme cold, but true, prolonged hibernation has not been seen by us in Queensland. Some reported cases of *Dysdercus* hiding in fence posts and similar places proved on investigation to refer to adults of *Aulacosternum nigrorubrum*, Dall.

2. Description of the various stages.

Adults.

Antennae black, legs black with coxae reddish brown, rostrum black. Abdomen, when newly adult, ventrally shining white, becoming yellow and finally orange with age. The last segment shining black in the females and in the males shining black with the caudal margin white, and the genitalia reddish brown. In the thorax the episterna are white and the epimera black. Head brick-red with tylus and eyes black. Prothorax with the cephalic margin white ; lateral margins, which are raised, brick-red ; immediately behind the white collar a transverse black band occupying one-fifth of the length of the thorax ; the remainder of the thorax cinnamon, grey brown, or buff, according to age. The scutellum is black. Hemelytra coloured like the thorax, having a black, centrally placed spot on each, which may be conspicuous or minute. Winter specimens tend to be very dark brown, almost black, but become lighter with age. The membrane is very dark green.

* *B. diversifolia*, *B. rupestris*, and *B. acerifolia*.

Males 10–13 mm. in length. Females 12–13·5 mm. Antennae, greatest length 8·9 mm., least 7·5 mm. ; average of 10 males and females, 8·02 mm.

Food-plants : Occasionally seen feeding on a wilga seed on the ground, never observed on wilga trees (*Geijera*) ; *Sida* spp., *Malva parviflora*, *Malvastrum* spp., *Melhania incana*, *Abutilon oxycarpum*, *Brachychiton rupestris*, *B. diversifolia*, *B. acerifolia*, *Hibiscus* spp., cotton.

Eggs.

In shape the eggs are similar to small hen's eggs, and at the broader end bear a ring of tubercles varying in number from five to eight, but usually seven. An average of 20 eggs gave the length of 1·27 mm., and 0·85 mm. as the greatest diameter.

When first laid the eggs are of a pearly colour but become faintly and then deeply orange as incubation proceeds. When the eggs are taking 7–8 days to hatch, this change is noticeable after the third day. The effect of temperature and moisture on eggs is discussed in another section of this paper.

When oviposition takes place the first eggs are laid at intervals of 10 seconds, but later the rate is much more rapid. As a general rule the male pesters the female, in captivity, when she is trying to settle down for the purpose of oviposition, but leaves her alone once she has really started. She often takes efficient precautions by hiding under cotton seed or some similar objects to prevent him from reaching her.

First Instar.

Length 1·6–1·7 mm. Antennae four-jointed with the distal joint the longest ; first joint 0·196 mm., second 0·183 mm., third 0·146 mm., fourth 0·464 mm. ; average total length of antenna, 0·96 mm. The rostrum reaches to the first abdominal segment, and the stylets can be clearly seen through it.

Hatching takes place through the egg-shell splitting longitudinally. At first the little nymphs are very feeble and coloured a pale yellow, becoming orange as they approach their first moult. Very rarely an extra moult takes place a day or two after hatching, but this does not interfere with the normal first instar period (4 days in the summer months). Nymphs of this instar never feed, but must have moist conditions in order to survive. They usually remain clustered in one spot.

Second Instar.

Legs and antennae sooty brown, head and thorax shining black. Abdomen crimson (paler when fed on seeds of *Brachychiton*), with three stink-gland orifices ringed with black. The cephalic margin of the prothorax is white, and a pale longitudinal line bisects the dorsum of the thorax. Eyes dark red. Anal opening black. Anterior femora with two toothed projections subapically. The rostrum reaches to the middle of the third abdominal segment. The fourth antennal joint, as in all succeeding instars, is closely set with long stiff hairs—in this instar 0·044 mm. in length.

Fifteen specimens gave the following measurements of the antennal joints : first 0·41–0·49 mm., second 0·41–0·46 mm., third 0·30–0·36 mm., fourth 0·74–0·83 mm. ; average total length, 2·15 mm. Total length of this instar shortly before moulting, 3 mm. ; recently moulted, 2·77 mm.

In this instar the nymphs are active and feed on cotton or on the seeds of other food-plants ; they will also feed on the stems of different Malvaceae. The duration of the instar varies from 4½ to 5 days in the summer to 20 days in the winter : in the latter case the nymphs did not complete their development.

Third Instar.

Antennae, legs and thorax fuscous, cephalic margin of the prothorax white. The thorax is bisected by a thin longitudinal white line. Abdomen dorsally brick-red, flattened soon after moulting, as in all instars, later swelling and becoming rounded. Orifices of the stink-glands black. Rostrum reaching the third abdominal sternite. Ventrally the abdomen is paler, the sternites of the thorax and the first two abdominal sternites yellow. The fifth abdominal tergite is much enlarged. Anal orifice black. Near the distal end of the anterior femora on the ventral surface a double spur of which the distal one is the larger; proximally a smaller single spine barely distinguishable in this instar.

Measurements. Body 4·5 mm. Antennal joints: first 0·60–0·83 mm., second 0·71–0·77 mm., third 0·48–0·53 mm., fourth 1·01–1·15 mm.; average total length, 3·08 mm.

Fourth Instar.

Colouring of thorax, head, antennae and legs as in previous instar. Eyes deep red. Abdomen dorsally pale cream with the anterior margins suffused with brick-red. Stink-gland orifices black. Ventral colouring like the dorsal, but the red suffusion more restricted. A black spot in the middle line on abdominal sternites 5, 6, and 7, that on 5 very inconspicuous and that on 7 the largest, being twice the size of that on 6. The rudiments of the wings are discernible in this instar.

Measurements. Body 6·8–7 mm. Antennal joints: first 1·3 mm., second 1·3 mm., third 0·8 mm., fourth 1·6 mm.

Fifth Instar.

The wing rudiments reach to the middle of the third abdominal segment. Head very dark brown to black. Eyes red, and a small red spot above and below each eye. Apices of the femora reddish brown, also a reddish brown spot at the articulation of the first antennal joint. Coxae yellow, episterna of first and second thoracic segments yellow edged with black, of the third thoracic black, epimeron shining white. Wing pads black. Prothorax edged with white. Abdomen dorsally and ventrally yellowish white, dorsally suffused with brick-red, the distribution of the colour becoming more restricted with age; the orifices of the stink-glands and anus black; black spots on the venter as in the preceding instar, but proportionately larger.

Measurements. Body 8 mm., just before moulting 10·8 mm. Antennal joints: first 1·8 mm., second 1·72 mm., third 1·12 mm., fourth 2·13 mm.

This instar, as in the case of the others, collects in large groups before moulting (Plate xix). Moulting is as a rule rather more irregular than in the other instars even in the summer.

All instars immediately after moulting are coral-pink. When moulting the skin splits along the thorax and the nymph pulls itself out, the legs and antennae coming out of the old skin last. In cold weather, and to a certain extent when reared in the dark, moulting appears to be attended with some difficulty, and the posterior legs and sometimes the antennae often adhere to the exuviae.

3. Habits of Nymphs and young Adults.

All stages from the second instar upwards feed on seeds of Sterculiaceae and Malvaceae. They do not seem so dependent on a mixed diet of green and ripe fruit as are the adults. Fifth instar nymphs scatter a good deal while feeding, but collect in groups before ecdysis takes place, individuals detaching themselves from the group when about to moult. This latter process lasts from 13 minutes in the final

ecdysis for females, and 18 minutes for males; and normal colouration is assumed in about 1½ hours. All stages cease feeding for about 24 hours before and after moulting.

Adult pairs do not get into copulation for 3 or 4 days after moulting in the summer, and then only if seeds are available. This is when fed on cotton. On *Sida* and *Malvastrum* and allied genera copulation is further delayed, as it is also at low temperatures. When no seeds are available sex consciousness does not seem to be aroused.

4. Egg-laying Habits.

The eggs are invariably laid in a mass in the ground in loose soil as much as one inch below the surface, or they may be put under some such protection as a piece of wood lying on the ground or, in one case observed, under a box that had been left in a large field cage. Shade and shelter of some kind are usually sought by the gravid females.

In the field the males are evaded and the female walks down from her food-plants and lays her eggs in peace. In the laboratory, however, it was often noticed that the males pestered the females and interrupted the process of oviposition; in consequence, they often had to be removed when the females showed signs of wishing to dig.

The intervals between the batches of eggs vary with the temperature, and to a certain extent with the food. In cold weather the intervals are very long and become shorter and shorter as the summer advances, until a minimum of 4 to 3 days is reached. The number of eggs laid at a time varies with the individual, and sometimes large numbers of eggs in each batch are infertile. One or two cases were encountered when a female became egg-bound, enormously swollen, but quite unable to get rid of her eggs. These females lived for a considerable time in what must have been acute discomfort. One such lived for 70 days and died without laying.

There were no indications that the last laid batches of eggs contained a higher percentage of infertile eggs than earlier ones, or *vice versa*. One case was observed of a completely barren female that laid no eggs but was often seen in the act of copulation. A female will continue to lay fertile eggs for the remainder of her life after only once being fertilised. A larger proportion of such eggs is infertile than with normal breeding pairs, but some fertile eggs are to be found in each batch.

Tables are given showing typical examples of the number of eggs laid in winter and summer and when the parents fed on different food-plants. All those fed on cotton seed were bred from nymphs reared in the laboratory, the B.01 etc., series being descendants of the B. series which had become adult in the previous autumn and early winter.

Below are given notes on oviposition as they were made in the laboratory.

11 a.m. Female showing signs of wishing to dig. 11.10, digging by the water cup, pushing aside a seed which was touching it; was then disturbed by male. (When looking about for an egg-laying place great use is made of the antennae, which are brought forward and downward, feeling here and there.) 11.15, the male made a frantic effort to get into copulation, the female shook him off by crawling under a seed. 11.20, she came out again and wandered about and began to dig energetically at the margin of the sand in the cage, feeling with her antennae and using her anterior legs with vigour. Made a hole and then left; returned to place where she had just dug. The male again approached and disturbed her. He was removed at 11.25, as he had become a nuisance. The female then cleaned her tarsi, rubbing median and posterior tarsi together and the anterior tarsi against the median. Started wandering again, remained still for a time and then had another clean up, this time using all three tarsi

TABLE I.

Some typical Egg-laying Records. Spring, Winter and Summer, 1926–27.

Date of female becoming adult.	Put with male.	First copulation.	Dates upon which eggs were laid. Number in each batch in brackets.	Total eggs.	Death of female.	Remarks.
20.x.26	20.x.26	26.x.26	8.xi.26 (71), 12–13.xi.26 (76), 15–16.xi.26 (78), 18.xi.26 (80), 21–22.xi.26 (64).	369	22–23.xi.26	
20–22.x.26	22.x.26	24.x.26	1.xi.26 (50), 4–5.xi.26 (22), 5.xi.26 (62), 10.xi.26 (80), 15–16.xi.26 (60).	274	18–19.xi.26	
20.x.26	20.x.26	24.x.26	29.x.26 (55), 2–3.xi.26 (151), 8.xi.26 (109), 13.xi.26 (101), 18.xi.26 (106), 21.xi.26 (96).	618	30.xi.26	
15.x.26	20.x.26	23.x.26	26.x.26 (88), 31.x.26 (109), 5.xi.26 (101), 10.xi.26 (104), 15.xi.26 (96), 20.xi.26 (77), 25.xi.26 (67).	622		
20–22.x.26	23.x.26	26.x.26	1–2.xii.26 (122), 6–7.xii.26 (112), 11.xii.26 (106), 16.xii.26 (114), 21.xii.26 (107), 26.xii.26 (85), 31.xii.26–1.i.27 (74), 4–5.i.27 (71), 9.i.27 (33), 14.i.27 (22).	856	21.i.27	34 dissected from female after death
19–20.x.26	22.x.26	28.x.26	1.xii.26 (107), 3–6.xii.26 (109), 11.xii.26 (105), 22.xii.26 (112), 26–27.xii.26 (86), 1.i.27 (96), 4.i.27 (82), 9–10.i.27 (53), 15–16.i.27 (66), 21–22.i.27 (46).	862	31.i.27–1.ii.27	Highest number recorded.
14–15.iv.26	14.iv.26	16.iv.26	25–26.iv.26 (87), 3–4.v.26 (86), 12–13.v.26 (48),* 30.v.26 (13).	234	30–31.v.26	* All but three infertile.
11–12.v.26	12.v.26	19.vi.26	24–25.vi.26 (70), 13–14.vii.26 (68), 3.viii.26 (64), 17.viii.26 (45).	247	18.viii.26	
4–5.v.26	6.v.26	11.v.26	29.vi.26 (72), 20.viii.26 (74), 8–9.viii.26 (58), 22.viii.26 (55), 1–2.ix.26 (60), 13–14.ix.26 (57), 22–23.ix.26 (47), 30.ix–1.x.26 (49).	475	10 or 11.x.26	
13–14.v.26	14.v.26	22.viii.26	1.ix.26 (60), 13–14.ix.26 (70), 21–22.ix.26 (67), 28–29.ix.26 (65), 5–6.x.26 (59), 10–12.x.26 (48), 18–19.x.26 (32).	401	23–24.x.26	

of one side at once. Began digging again at one side of the cage where she had tried before, did not like it and left. 11.35, came back, identified the spot with her antennae and started digging again, and again gave it up and had another clean up. Then began digging in another place at the edge of the sand and then wandered off. At 11·43 digging again at the second hole, which was becoming quite big. Observation ceased at this time when she was again wandering (11.45). She had not laid an hour later. When next observed (2.36 p.m.) she was just scraping sand over her eggs, which had been laid near the water cup. She appeared very excited, running about with little jerky movements, feeling here and there with her antennae and now and then scraping up a bit more soil. She appeared to be trying to make quite sure that everything was well hidden. She then hid herself under the paper bearing the cage number. This she left later and performed her little dance over the spot where the eggs had been laid.

TABLE II

Month.	No. of observations.	Average interval between dates of laying in days.	Mean temperature for the month.
March	14	5·7	75·7
April	3	6	71·5
May	8	10	65·3
June	8	18·25	61·4
July	16	19·8	58
August	21	13·6	63·5
September ...	17	11·1	66·8
October	3	5	72·2
November ...	57	5·1	75·9
December	62	5	77·4
January	17	4·9	78·8
February	30	4·5	78·8

5. Feeding Habits.

Dysdercus sidae seems to be able to support life on a variety of plants, but chooses chiefly those belonging to Malvaceae or Sterculiaceae. It is an insect of an experimental turn of mind and will try all sorts of seeds as food, but for a regular diet it confines itself to the plants of the orders named.

Nymphs and adults show some differences in the type of food which is necessary for their well-being. Adults must, except when fed on the seed of cotton or *Brachychiton*, have a mixed diet of ripe and unripe fruit to become sexually mature and lay fertile eggs. Nymphs on the other hand thrive well on ripe seeds until stage V is reached, when the desire for green food becomes apparent. Usually the adults select food-plants that are in such a stage that there are flowers, some immature fruits and ripe fruit, that is to say, at the time when fruiting is beginning. A sudden period of dry weather which might check the flowering of one species of plant will drive them to another on which the fruit is in a stage more palatable for them. An example of this was observed in the present season when the first migrants chose *Abutilon oxycarpum* for their food-plant and fed on it almost to the exclusion of everything else, until dry weather ripened all the capsules and checked flowering. At this time *Malvastrum spicatum* was in flower, and *Dysdercus* turned to it and *Sida subspicata*. After the next fall of rain *Abutilon* began to flower again, and *Dysdercus* returned to it as soon as green capsules were formed.

Nymphs from eggs laid at the foot of bottle trees (*Brachychiton rupestris*) feed on the fallen seeds in ripe capsules and later (in the fifth instar) spread out to feed on *Sida corrugata* growing in the vicinity.

In cotton fields all stages (except the first instar) feed on the seeds of open or preferably just opening cotton bolls. Adults feed on the green bolls, sometimes only piercing the boll wall, at others thrusting their stylets in " up to the hilt " in the evident desire for the seeds. Green bolls alone, however, do not lead to fertility, until after the boll is full-grown but still green, *i.e.*, about the 33rd day.

It was found in the laboratory that bugs fed on *Sida retusa* laid eggs less frequently, and of a much smaller percentage of fertility than when fed on cotton seed. Cotton seed was used for food for all the routine breeding observations and gave the highest percentage of fertile eggs and the largest number of eggs.

Adult bugs do not become sex conscious until they have fed on seed. When pairs were kept on cotton seedlings no copulation took place, but as soon as cotton seed was given them they were in copulation within 24 hours.

Both adults and nymphs were just able to live on crude cotton seed oil,* but throve quite well (as well as on *Sida retusa*) when fed on cotton seed cake containing 6 per cent. of oil. The seeds of *Brachychiton rupestris* provide as good nourishment as cotton seeds up to the fifth instar, but nymphs are slightly smaller and in the earlier instars more orange red than sanguineous, as in the case with those fed on cotton seed. Cotton seed alone, so far as experiments have gone, gives all stages the food they need. This would account for the very rapid increase in population once the bugs become established in a cotton field.

When *Dysdercus* was first found in the summer of this year (1927) at the Cotton Research Station at Biloela, nymphs and adults were feeding on the fruit and seeds of " bottle trees " and on no other plants. Later they spread to *Sida* and *Abutilon* near the trees. When last seen in the previous winter, in July 1926, they were feeding on *Melhania incana* (Sterculiaceae). This little plant was flowering and fruiting from September onwards, but it was not until the middle of March that *Dysdercus* was seen to feed on it again. It almost seemed that in that area the kurrajong (*Brachychiton diversifolius*) and bottle trees, and perhaps the maple-leaved bottle tree (*B. acerifolius*), formed the winter host.

Possibly they went from kurrajongs to bottle trees, as the former is said to flower first. Information as to the life-history of the various host-plants of *Dysdercus* is so meagre that suggestion is all that can be made. In the southern areas in late winter and early spring (August and November) *Dysdercus* adults and fifth instar nymphs were feeding on *Sida* and *Malva* along an irrigation channel. The particular locality in question is one which has been settled for a considerable time and bottle trees or kurrajongs are far away. Presumably species of *Malva*, *Sida* and *Malvastrum* supply the requisite food in the winter in such localities.

Nothing that we have seen lends any support to the suggestion that *D. sidae* is attracted to cotton from any distance, or that the opening of the bolls plays any part in bringing them into the crop. So long as *Abutilon* was to be had, *Dysdercus* was to be seen feeding on it and leaving a field of cotton full of opening bolls untouched, although separated from it by nothing more than a barbed wire fence and at places even alongside it. It was only after the drying up of the *Abutilon* that that bugs began to be found in this field. The preference shown by migrants of both the first and second migration for *Abutilon* was most marked. It does so happen

* Nymphs fed on crude cotton seed oil developed up to the third instar and there stopped. Fourth instar nymphs which were given crude oil just after moulting did not develop, although they lived and were active. Their colouration was pale, as though they had only recently moulted.

that as a rule the arrival of the first migrants coincides with the opening of the cotton, but everything points to this being a coincidence and nothing more. The bugs would be in the same place if no cotton were there, and they simply find the cotton in the course of their migration, as they would any other food-plant. Long after cotton was open any number of bugs could be found close to the fields feeding on *Sida* and *Malvastrum* and other Malvaceae. They have been found in fields with only one or two bolls opening and not found when bolls were open and opening in large numbers.

Cotton suffering from lack of rain or excessive rain is no worse affected than cotton in a healthy condition. In the year when the cotton crop was at its best, *Dysdercus* was most numerous. Drought-stricken cotton is abandoned, as it ceases to provide food and shelter, and this applies to the wild food-plants in the same condition.

When feeding on open bolls *Dysdercus* usually prefers the seeds at the base of the boll, and it is common to see all stages packed into this narrow space when there was ample room for all to feed in comfort had they chosen to spread themselves over the whole boll. Similarly many nymphs will crowd around and fight over one seed of *Brachychiton* when there are plenty of seeds lying about.

When nymphs are given a choice of cotton seed and split kernels, particularly if the latter are freshly cut, they choose the kernels, betraying great excitement. This attractiveness persists for days, and given complete freedom of choice nymphs will always feed on the kernels to the exclusion of the unhusked seed. Boxes of split kernels placed amongst cotton will attract some numbers of nymphs, but adults not so commonly.* Up to the time of writing this method of attracting nymphs does not show any prospect of being useful as a means of control, owing to the large number of traps which would be required.

It is a very favourite habit of both nymphs and adults to carry off seeds to feed on at their leisure. Very often a fight arises from this cause, the possessor of the seed defending itself and its food with its proboscis, a weapon *Dysdercus* is always ready to use when sufficiently provoked.

Adults and nymphs will suck flowers of different species, apparently for the nectar. Except during cold weather, *D. sidae* is a very thirsty creature and in the laboratory drank frequently from the water cups or damp blotting paper with which the jars and dishes were furnished. In the absence of moisture they will kill one another to get it. During copulation males rarely feed, the females doing so frequently. After egg-laying, females feed hungrily for some hours and generally manage to evade the males during this period.

Although the exact distance cannot be recorded, the impression is that the attractiveness of any particular type of food does not extent over a very great area, a yard or two at most, and shade and moisture seem to be the first consideration, food taking second place in influencing movements. The following notes are of some interest in this connection : —

A pair had been confined in a lamp-glass and given cotton seedlings as their only food. On this they fed for seven days. A cotton seed was then put in. At that time the female was feeding on the leaves of the seedling. When the seed was introduced she showed signs of excitement, and ran about waving her antennae ; then settled down to feed again. Twenty-five minutes later she again became restless. Then she suddenly seemed to get the "scent" of the seed and came hurriedly

* Nymphs are always busily running about on the ground or climbing up and down the plants, and are thus more likely to come upon traps than would adults.

down from the seedling and immediately began to feed. This took place half an hour after the introduction of the seed.

When cut kernels are put into a jar containing *Dysdercus* nymphs, particularly if they are hungry, intense excitement prevails. The nymphs run about and then cautiously approach the heap of food, holding their antennae straight out in front side by side. They go up to the kernels and then run away again until one bolder than the rest rushes in and begins to feed, the others follow and very soon all are feeding eagerly. (It might be mentioned in passing that in any group of nymphs there are always one or two more enterprising or more inquisitive than their fellows, and in the presence of anything unusual, such as strong scent, the others wait for a lead from these bold ones.)

Terpineol and trimethylamine acted as repellents rather than attractants. To citronella oil *Dysdercus* showed a most marked aversion. Refined cotton seed oil and crude cotton seed oil did not attract. Crushed kernels (cotton seed) were fed on when hung in cotton bushes on which open cotton was present, but failed to attract in the following season. The figures for the first experiment were as follows : Four lots of bait of one ounce each hung on the plants—3 for three days, 1 for six days ; a total of 202 bugs was found ; similar amounts of cotton seed meal attracted in the same time 40 bugs. When the baits were hung on stakes among the plants the figures were 70 and 23 respectively for kernels and meal ; 3 baits were on stakes for 6 days each and one for 4 days.

Species of *Sida*, *Abutilon* and *Malvastrum* are always to be found under shade, but, in the summer at least, these species when growing in the open will not exert any attraction, and no *Dysdercus* will be found on them. In the autumn and winter feeding in the open is more common.

A very marked characteristic of *D. sidae* is its proneness to cannibalism. Not only is this shown in the absence of food and moisture, but in the presence of sufficient amounts of both. Not invariably, but usually when a brood takes to cannibalism the survivors do not long outlive their victims. It appears always to be a symptom of a pathological condition. There is no evidence that it is hereditary, and the very few adults that we were able to rear from cannibal nymphs produced eggs giving normal nymphs, with no greater tendency towards cannibalism than others from non-cannibal parents. Cannibalism occurs commonly in the field* and is not the result of unnatural laboratory conditions. In a breeding jar males or females will suck newly laid eggs, if they can get at them, but a female will not suck her own. Besides feeding on its own species, *D. sidae* has been seen sucking pupae of *Earias hugeli*, and on one occasion, a fly caught in a spider's web.

When investigating food or egg-laying places, or strange objects, great use is always made of the antennae, and the object under examination is felt all over with their tips. When water is put into a jar with nymphs which have been deprived of it for some time, they seem to get the scent of it at once, and the antennae held close together are pointed towards it.

When feeding, the rostrum is either used as a guide for the stylets, or it is folded under the abdomen, the stylets being free. This method is adopted when feeding on a green boll and sometimes on cotton seed. When feeding is completed, the rostrum is swung forward and the anterior legs used to replace the stylets in their sheath.

Tables III–V show the influence of food-plants on egg production and the length of nymphal life and should be compared with egg-laying records of the same dates given in Table I.

* The smaller nymphs were usually the assassins, fourth instar nymphs attacking the fifth, or fifth and third instars attacking adults.

TABLE III.

Egg-laying Records of Pairs fed on Sida retusa.

Date of becoming adult.		Date when mated.	Dates of laying and number of eggs.	Total no. of eggs.	Date of death of	
Female.	Male.				Female.	Male.
17.xii.26	17.xii.26		6.i.27 (37)	37	15–16.1.27	2.iii.27
17.xii.26	17.xii.26		4.i.27 (17)	17	8.i.27	?
17.xii.26	17.xii.26		5.i.27 (18)	18*	8.i.27	?
17.xii.26	17.xii.26		none	—	31.xii.26	?
17.xii.26	17.xii.26		none	—	do.	?
15.i.27	15.i.27		none	—	23.i.27	?
8.i.27	8.i.27		19.i.27 (53) 28.i.27 (23)	76	30.i.27	?
8.i.27	8.i.27		19.i.27 (59)	59*	28.i.27	?
22.i.27	17.xii.27		8.ii.27 (56)	56*	12.ii.27	2.iii.27
28.i.27	8.i.27		none	—	7.ii.27	7.ii.27
30.i.27	8.i.27		8.ii.27 (61)	61	10.ii.27	9.ii.27

* These eggs alone hatched; 20 pairs used in all, only 7 of which laid any eggs.

TABLE IV.

Pairs fed on Brachychiton rupestris *seeds.*

Date of becoming adult.		Mated.	Dates of egg laying and number of eggs.	Death of	
Female.	Male.			Female.	Male.
16.ii.27	16.ii.27	17.ii.27	28 or 27.ii.27 (106), 3.iii.27 (54), 12.iii.27 (54), 29.iii.27 (38), 13.iv.27 (58). Total, 310.	19.iv.27	17.iv.27
16.ii.27	16.ii.27	17.ii.27	24.ii.27 (100) mostly collapsed. Total, 100.	2.iii.27	?
4.ii.27	14.ii.27	14.ii.27	1.iii.27 (36). Total, 36.	6.iii.27	?
1.iii.27	2.iii.27	2.iii.27	6.iii.27 (54), 13–15.iii.27 (73), 20.iii.27 (35, and some sucked), 2.iv.27 (9). Total, 171.	3.iv.27	10.iii.27
1.iii.27	4.iii.27	6.iii.27	Nil.	11.iii.27	?
9.iii.27	8.iii.27	10.iii.27	Nil.	17.iii.27	?

TABLE V.

Nymphs from same Batch fed on Cotton Seed and Sida retusa.

Serial No.	No. of eggs.	Period of IV instar.	Period of V instar.	No. of adults.	Food.
E S 10	24	11–12 days	10 days	4	*Sida.*
Control	24	5 ,,	10 ,,	22	Cotton.
E S 8	40	11 ,,	15 ,,	9	*Sida.*
Control	41	7 ,,	8–8½ ,,	26	Cotton.
E S 5	25	4–4½ ,,	10 ,,	13	*Sida.*
Control	25	4 ,,	8 ,,	7	Cotton.*
E S 6	35	5 ,,	9–9½ ,,	6	*Sida.*†
Control	35	5 ,,	8½ ,,	14	Cotton.
E S 4	13	7–7½ ,,	10½ ,,	12	*Sida.*†
E S 11	33	7–8 ,,	16 ,,	4	*Sida.*‡

* This was not a vigorous batch and there was much cannibalism in the second instar.
† Nymphs and adults undersized compared with those fed on cotton seed.
‡ Parents fed on *Sida.*

It will be observed that the effect of the food in these examples was shown only in the third and fourth instars, although all nymphs fed on *Sida* and adults from such nymphs were smaller than those which had been fed on cotton and had not the same robust appearance.

6. Response to Climatic Changes.

Some attention was paid to the responses of *Dysdercus sidae* to climatic changes in the hope that light might be shed on the causes of scarcity in certain seasons, or at least to lay the foundation for more extensive investigations.

The greatest difficulty encountered was that of studying the influence of differing relative atmospheric humidity at constant temperatures. This difficulty, with the means at our command, we were unable to surmount.

The incubation period of the eggs alone gave any definite results and even in this case did not get one much further than the knowledge that a low humidity retarded development by some hours, and in certain cases by as much as a whole day, as compared with either a saturated atmosphere, or a humidity of 65–75 per cent.

First instar nymphs do not feed, but must have humid conditions in order to survive. High humidity has the same effect as cold in that nymphs making their last moult under such conditions produce very dark adults, which, however, become paler with age.

A short spell of very hot dry weather in 1925, when temperatures of over 100° F. were experienced, was accompanied by a diminution in the numbers of *Dysdercus*, and many adults were found dead. In the incubator even when drinking-water was available but the atmosphere dry, temperatures of 104° F. and over proved fatal to imagines and eggs. The eggs were killed at mean temperatures between 90° and 96°. Nymphs survived rather higher means as the curves show.

Torrential rains, such as those which were experienced in the present season (1927) from midsummer onwards, are undoubtedly fatal to eggs and the earlier instars. Eggs kept for 24 hours in a saturated soil failed to hatch, as did those in conditions of extreme dryness.

The *Dysdercus* bugs which came to the experimental cotton plot in Brisbane in 1926 when the long drought began failed to attain any marked increase in numbers, and at the end of the season their descendants were very difficult to find—a definite contrast to the more favourable season of 1924–25.

It would seem that the atmospheric conditions of the Queensland coastal belt would be very suitable for *Dysdercus*, as the humidity is generally high and extremes of temperature are rarely experienced.

Stainers have been observed to be breeding in July at a place on the central Queensland coastal area, when inland behind the coastal ranges they would be unable to reproduce. For this reason a high percentage of stained cotton due to internal boll-rots could always be expected from such localities.

However necessary a certain amount of atmospheric moisture may be, small changes of temperature have a more marked effect on development than small changes of humidity.

In order to study this a number of broods were carried through the year in the laboratory from March 1926 to May 1927. In addition a multiple temperature incubator was employed. This incubator was made from the design of that used by the Entomological Section of the Ministry of Agriculture, Egypt.*

* C. B. Williams & T. W. Kirkpatrick, " A Multiple Temperature Incubator."—Technical & Scientific Service Bulletin no. 38, Cairo, 1924.

It was found that constant temperatures could not be maintained, and there was sometimes a rise and fall of six or eight degrees. This, however, was of no consequence and was in some ways an advantage, as it approximated more closely to natural conditions. The results obtained agreed in general with those of the different periods of the year when similar mean temperatures prevailed.

From a combination of these two methods of study the following facts were obtained (figs. 1–6).

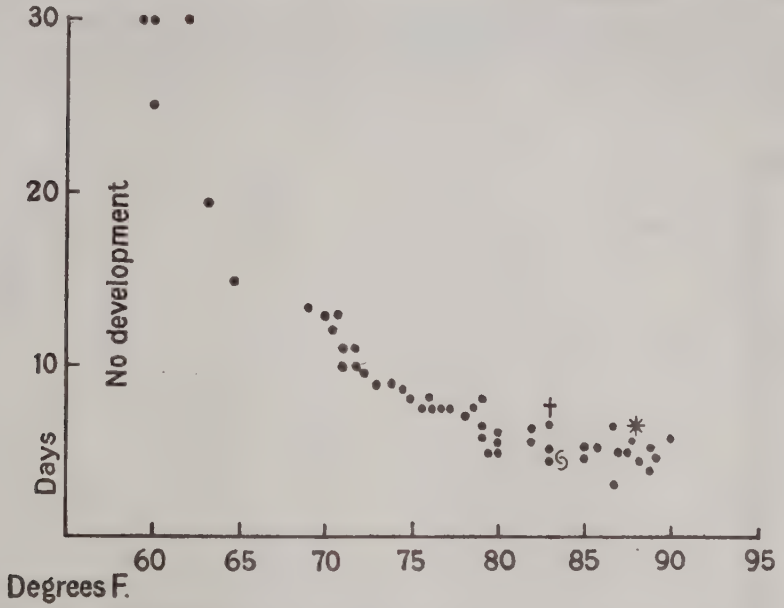


Fig. 1. Incubation period of eggs. † Maximum for one day 95° and 90° on another; most of the broods died as embryos. § Maximum 89°; 100 per cent. hatched. * Exposed for several hours to 96°; several died as embryos.

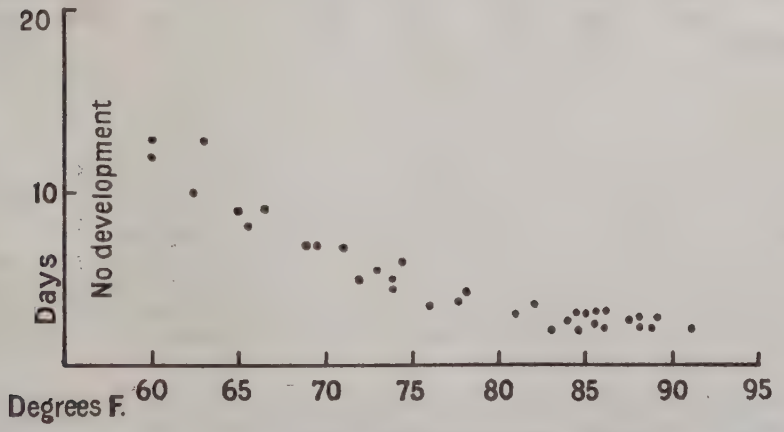


Fig. 2. Developmental periods of first instar nymphs.

A study of these curves shows that development between 68° and 85° F. is progressively regular. Third and particularly fourth instar nymphs showed great irregularity at all temperatures, and every instar became irregular at low temperatures; that is to say, instead of the whole brood moulting within a few hours, the process often took a day or two. This was particularly noticeable with the fifth instar turning to adults. In the case of the fourth instar, it almost seems that there are alternative curves of development coinciding at about 84° to 85° F., one always longer and the other shorter.

The curves for the fifth instar and the incubation periods are the most accurate. Some irregularities occur in the latter, as humidity plays an important part in influencing development, more so than in other stages, and this factor we were unable to control.

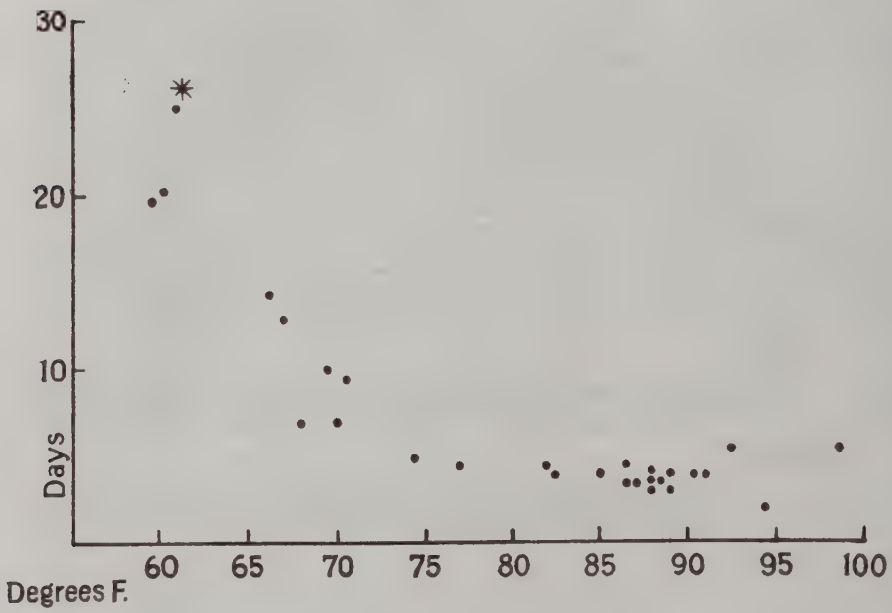


Fig. 3. Developmental periods of third instar nymphs. * For the first 16 days the mean temperature was 60°, for the remainder 64·2°.

In all cases except instars II and III the optimum temperature appears to be between 84° and 85° F., after that a definite retardation is indicated. Mean temperatures above 95° were generally fatal; at most there were only one or two survivors in the brood,* and in the case of adults the males usually died first.

Insects which became adult in the incubator at high temperatures resembled those produced under natural conditions during the summer, while at the same period in the laboratory (mean temperature 67–65° F.) dark individuals were being obtained. During the summer months dark specimens could be produced by keeping fifth instar nymphs at a low temperature.

* One or two exceptions to this were noted after this paper had been written, where nymphs from eggs kept at as high a temperature as development permitted completed their different stages at temperatures which normally would retard or kill.

For nymphs and eggs the developmental zero was 60° F., and only temperatures above this point were effective. First instar nymphs subjected to a mean temperature of 54·5° F. for 25 days could not be induced to moult when raised to 65° F., but the other instars showed greater powers of recovery. No eggs ever hatched below 59° F., and even up to 63° only produced a low percentage of nymphs which survived beyond a few days, although embryos were formed.

Another effect of cold, apart from mean temperatures below 60° F., was that moulting became very irregular in all nymphal stages, and often difficulty appeared to be experienced in getting rid of the exuviae. Bugs becoming adults during the cold weather were much darker than those of the summer, even to being almost black ;

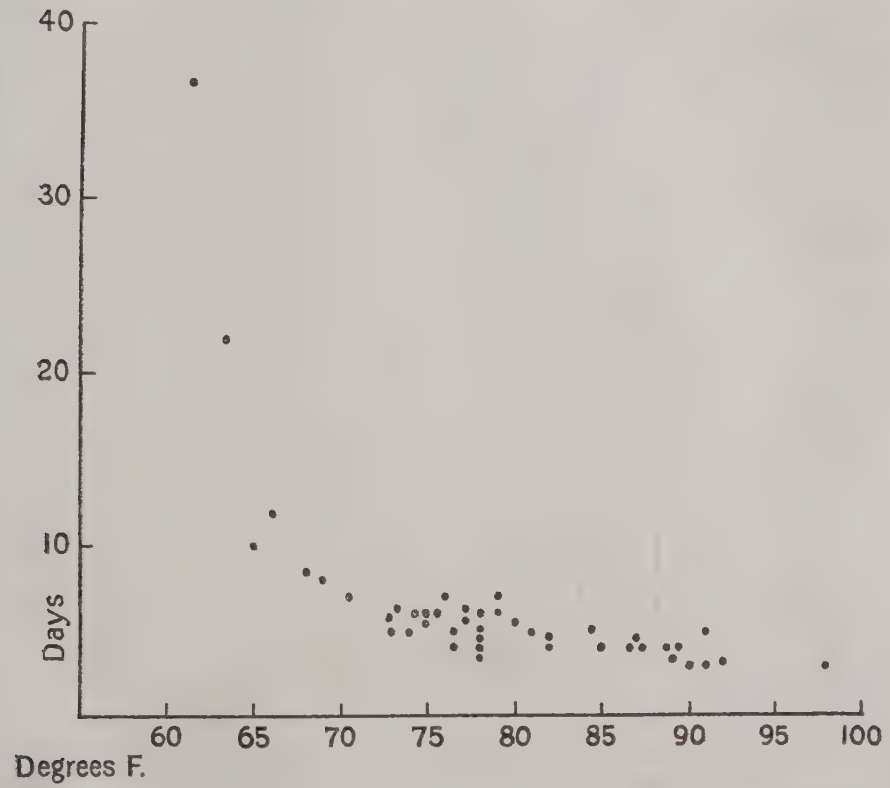


Fig. 4. Developmental periods of third instar nymphs.

they were also noticeably smaller. On the other hand, the adults of the late autumn and early winter lived far longer than the summer individuals, and fifth instar nymphs successfully survived the cold weather and produced healthy but rather dark adults in the spring.

In the laboratory egg-laying continued throughout the year, but as the weather cooled this took place at longer and longer intervals, varying from $3\frac{1}{2}$ days in the hottest part of the summer (mean temperature 77°–79° F.) to 19 days in July, the coldest month (mean temperature 58·1° F.). None of the eggs laid in late May,

June, July or August, were fertile,† or if fertile they did not hatch out, although the embryos were formed. Copulation lasted for a very long time in the winter months and the intervals between egg-laying and copulation were correspondingly lengthy. Adult bugs can apparently survive any cold that they are likely to experience in Queensland cotton-growing districts, and when kept on ice for a week, although comatose at the end of this period, they revived.

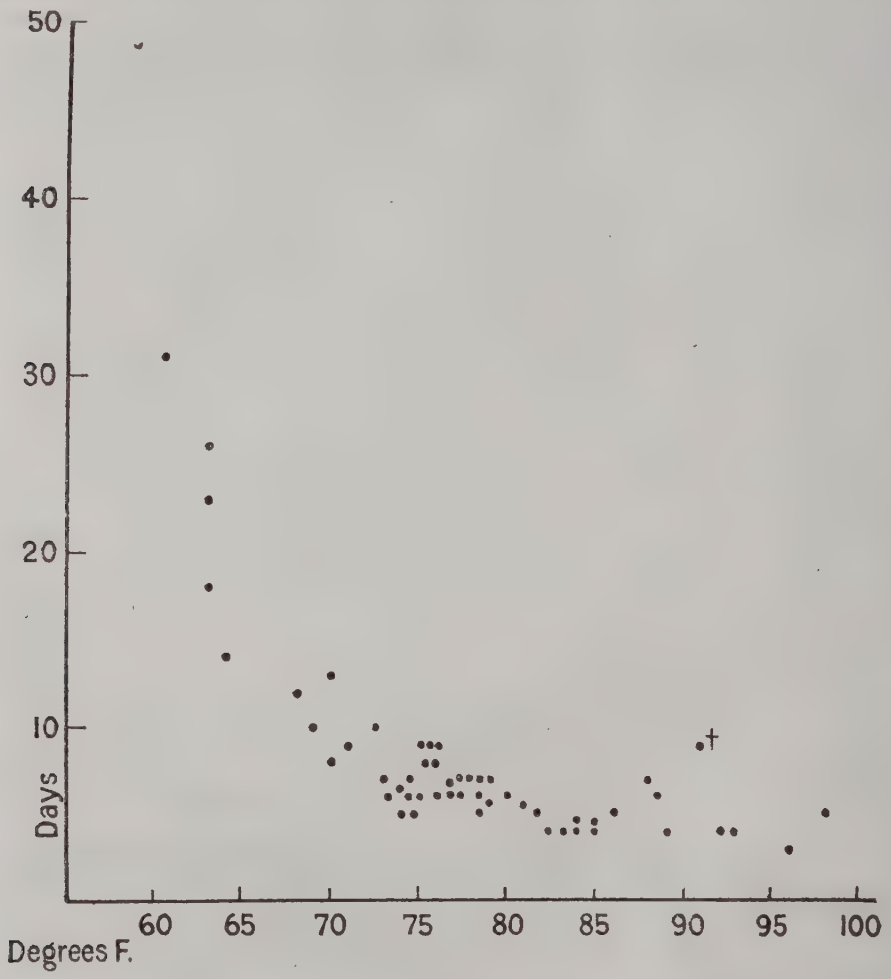


Fig. 5. Developmental periods of fourth instar nymphs.

Hibernation does not appear to take place, but temporary shelter may be sought during very cold weather, as it will be during heavy rain or excessive heat. Bugs have been found feeding at all times of the year, not only on the coast, but also inland at elevations up to 1,000 feet.

† This was not due to the spermatozoa being immobile, but to failure of the embryos to develop.

Dysdercus dislikes very high temperatures and on days when the maximum temperature is in the neighbourhood of 90° F. and over always seeks shade. During the very hot summer of 1926 a favourite resting place for all stages was the southern side of the large breeding cages set up in a certain field. During the hottest time of the day bolls were entirely deserted and such sheltered spots as the drought-stricken cotton plants afforded were always sought by those which did not go to the cages. Temperatures of 104° F. appeared to be fatal to all stages, and mean temperatures of 90–100° were fatal after three or four days, but such temperatures are rarely experienced in the cotton belt. The first instar responded more rapidly than others

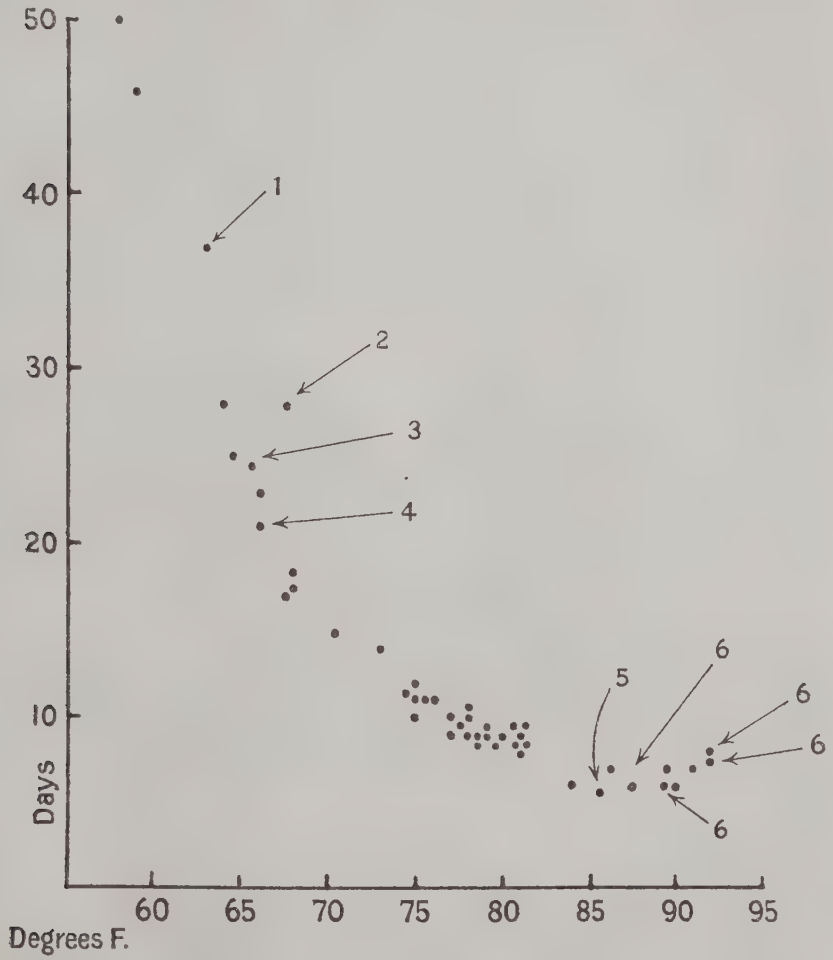


Fig. 6. Developmental periods of fifth instar nymphs: 1, average moult occupied 7 days; 2, average moult occupied 10 days; 3, one individual; 4, only one survivor; 5, fed on *Brachychiton* seed; 6, brood divided into two groups.
Two batches experienced a mean temperature of 98° (maximum 106°); began to die just before moulting; survivors moved to 80°–90° lived, but development was checked.

to a rise in temperature, as the long first instar period of the early spring rapidly falls to the 3½–4 days of the summer.

A brood of nymphs which has begun to moult, if put into a mean temperature of 55° F., would complete their moulting, but if put into such a temperature in the middle of that instar period, they would not complete their development. This was a point which one would have liked to have followed up had circumstances permitted, to ascertain the period of development when temperature change exerted its greatest effect.

Adults are most active on sunny days that are not too hot; for example, with a maximum shade temperature of 85° F. Bugs flying about on such a day will become quiescent when a cloud passes across the sun, resuming their activities when the sun shines again. Further notes on the effect of cloudy weather are given in the section on migration.

In determining the points on the graphs which illustrate this section, in most cases they were calculated from numbers of individuals, and only in the cases of incubation between the temperatures of 60° and 64° F. were single individuals used. The different periods for the five instars and the incubation periods are substantially accurate. That is to say, they are not correct to the nearest hour, but are so as nearly as was found practicable. Where, for example, an incubation period of 4 days is given, it might have lasted 96 hours or 100. It was not possible to be lucky enough always to see either the act of oviposition or the moment of hatching. Where the instars or incubation lasted for 15 days or more, the time shown on the graphs may be 12 hours out. Such observations were, however, near enough for our purpose and serve to illustrate the effect of winter and summer on the insects' metabolism.

To attempt to make any prophecies as to the weather conditions which will enable one to warn farmers as to probable appearance of *Dysdercus* or not would be rash indeed with the data at our command. During the last few years in Queensland there has been only one really favourable cotton season. In that season *Dysdercus* was early and abundant. The other seasons, as already stated, either began as droughts and ended in torrential rain, or began well and ended in drought. In each of these *Dysdercus* was late in arrival and only raised a large population when there was little cotton for it to damage. In the season 1926–27, when phenomenal rains were experienced after the break of the drought in December, *Dysdercus* arrived late and the first generation in the fields only moulted to adults in the beginning of May, when the cold weather had set in.

Knowing how much *Dysdercus* dislikes very arid conditions it is possible that the droughty time kept it back. But it must not be forgotten that many of the natural food-plants were late in fruiting, which would have an equally retarding effect. When evolving theories as to the effect of climatic conditions on *Dysdercus*, the effect of those conditions on its wild food-plants should not be overlooked, as anything that affects them will affect the numbers of *Dysdercus* likely to become migrants.

It would seem that much more data are required before the forecasting of *Dysdercus* migrations can be attempted.

7. Migration at Biloela, February-March, 1927. (By M. Gwen Evans.)

Throughout the months September 1926–January 1927, *Dysdercus* was reported to be very scarce in all districts under observation, and in most places it was impossible to find any. In the Laboratory, on the other hand, descendants of earlier captive pairs were flourishing as active broods during those months, and therefore the presence of *Dysdercus* in large numbers somewhere in the bush was climatically

possible, but it was not until 8th February that they were reported to be breeding actively on the seeds of bottle trees (*Brachychiton rupestris*) in the scrub in the Callide Valley, where the Cotton Research Farm is situated. They were entirely confined to the bottle trees.

In the scrub at Biloela itself the group at each bottle tree showed the same relative numbers for the different instars, as follows: Adults very numerous, second and third instars numerous, fourth scarce, fifth none. The arrangement suggested that the adults present had migrated to the trees of that area from some other area, possibly in denser scrub. This idea was supported by the result of an examination of the groups feeding on bottle trees at Thangool, six miles away in more recently cleared country. There adults were very scarce, but nymphs of all instars were numerous. It seemed very probable that in due time a migration might take place from the bottle trees in the Biloela scrub to the cotton fields near by, and it was the good fortune of the writer to be sent to the Research Farm to watch the movements of *Dysdercus*; with the help of the Manager of the Farm (Mr. Hodge) such a migration was actually observed in detail and the following is an account of it.

On the accompanying map, scrub country is clearly marked out from forest land, which in the neighbourhood of the Farm is mostly ring-barked to make way for cultivation. Bottle trees are found as typical members of the brigalow-wilga scrub, and when the latter is burnt to clear the ground for cotton, some bottle trees may survive the flames and remain standing for years. To the north and east of the map, scrub land continues for miles. To the south, forest country intervenes for a few miles and the dense scrub begins again and includes the Thangool area mentioned. To the west, forest country covers the flats for several miles towards the open plains.

An examination of the Biloela area was first made by the writer on 26th February, and the relative numbers in the different instars had changed since the report at the beginning of the month. Adults had become very scarce, whereas fifth instar nymphs formed approximately 80 per cent. of the total population, being the same individuals as those forming the dominant second and third instars of the earlier date. By using the time temperature charts of the life-history, as worked out in the Laboratory, the following deductions were made: That about 8th January *Dysdercus* migrants had reached the bottle trees in the Biloela scrub, coming from other bottle trees in such places as Thangool; that nearly all these original migrants had died, while the broods from the earliest batches of eggs had now entered the fifth instar; that up to date, no migration would have taken place from the Biloela scrub.

For detailed and daily observations one big bottle tree was selected, as offering a typical sequence of events that would be coincident with those taking place at the other bottle trees on the Ridge. The tree was still carrying a heavy crop of both ripe and unripe fruit, and in this respect was later than the other trees. A ladder was erected, giving access to the topmost branches of the tree, so that the movements of the bugs about the branches could be correlated with their behaviour on the ground. There was much coming and going by way of the trunk, but it was almost confined to the fourth and fifth instars, which fed from the open pods, while the second and third instars remained on the ground, sucking the seeds from the fallen fruits. It was impossible to estimate the total number of nymphs, which were scattered over the ground at the base of long grass and under logs and clustered on the small bushes of the undergrowth, but there must have been more than 10,000 feeding on or in the shade of the one tree. Later, when adults again became numerous, they also made their way up and down the trunk.

During the next few days the tree was examined twice daily and its immediate environment carefully searched. Many dead adults were picked up, and a count which was made of those on the ground at the base of the trunk, where they were most numerous, resulted in 52 per square yard. This result gave some idea of the

number of original migrants. A few adults were found, which were all fresh-looking, with the exception of one pair, which were in copulation and looked old. Moulting was going on in all instars from dawn to dark and the percentage of fifth instars became even higher than 80.

A large number of these fifth instar nymphs were seen radiating out to a distance of approximately 100 yards in all directions, save to the north-west, where food-plants were absent from the grassy undergrowth. They were making their way feeding on *Sida retusa* or carrying with them, by means of their proboscides, the seed of *Sterculia*. Within this circle, of 100 yards radius, the nymphs began to collect into groups under fallen logs or pieces of bark, or behind the peeling bark of dead brigalow trees. The behaviour of these groups suggested that they might function as units in migration, but this proved to be only partly true. During the day, the immature nymphs among them (recognised by their colour) were feeding near by, while the mature ones remained huddled together in the sluggish condition that had been observed in the Laboratory as characteristic of the few days preceding the last moult.

Within the area of that one bottle tree a sudden enormous supply of adults seemed imminent to form a mass migration, but the vast supply of fruit, still untouched and ripening, seemed capable of feeding all their progeny, so that it also seemed possible that any outward movement might not take place until brought about by economic pressure on some later generation.

Nevertheless, on the afternoon of 1st March, *Dysdercus* adults were found in the Washpool Gully, near to the cotton fields, feeding on *Abutilon oxycarpum* associated with *Sida retusa* in the shade of a tree. Since these were the first adults found anywhere outside the bottle tree communities, we surmised that they were the first migrants from the trees on the ridge, and their fresh appearance gave support to the probability of their recent arrival. On the following morning they were found on similar patches of *Abutilon* right up the Washpool Gully throughout a distance of $1\frac{1}{2}$ miles. Some were in copulation, but many were single, and the males, which were in excess, flew to and fro in short circling flights. All of them were fresh-looking. Such large numbers, if any, had certainly not left the observation tree, and therefore it seemed probable that all these migrants came from the communities at the other trees on the ridge, which had forestalled our chosen group by a few days.

On the afternoon of 2nd March moulting into adults proceeded at a great pace under the observation tree (six an hour on one small bush), but although a careful watch was kept, no flights were observed. On the contrary, the newly moulted adults, which had removed themselves from the huddled mass in order to cast off their skins, returned to the mass and lay in a lethargic condition amongst similarly lethargic fifth instar nymphs.

On the 3rd March, while the writer kept close watch at the tree where moulting continued rapidly all day, Mr. Hodge made a tour of the surrounding country, searching for *Dysdercus* and its food-plants. He established the following interesting distribution: *Abutilon oxycarpum* was flourishing in the scrub and in the forest country only under shade trees (barcoo wattle) along the water-course. *Sida retusa* was not so limited in its range, being found nearly everywhere in the neighbourhood of cultivation. The *Dysdercus* migrants were found on *Abutilon* almost exclusively, the few exceptions being in places where *Sida* was very closely associated with *Abutilon*. But no migrants were found on the *Abutilon* in the one piece of scrub examined, namely, that at the western end of the ridge. They seemed to be confined to the patches under shade trees along the Gully. Ripening cotton carrying open bolls was within the migration area, but had not attracted any *Dysdercus*. Three dominant factors seemed to have determined the distribution of the migrants: the water-course, the shade trees, and *Abutilon*.

Mr. Hodge also witnessed two cases of migration in which a single male, from a moulting group under a bottle tree, climbed to the top of a small bush and flew away to the north-east. Migration from the observation tree itself began the next day, and its course during the subsequent four days is represented by the accompanying graph (fig. 8), which illustrates only the movements of the largest of the many groups beneath the tree. But other more casual observations of other groups suggested that the graph might serve as a type. This group had chosen a small bush only two yards from the trunk of the tree and there awaited the migration impulse. It will be seen on the graph that rainy conditions prevailed during the early stages and seemed to delay the flight, which under normal conditions would probably have taken place before feeding and the consequent awakening of the sex instinct in the new adults. Many individuals made preparation for flight before any case of feeding was noted, and the sexes seemed quite unaware of one another. It was only after a few cases of feeding had been observed that a few males disturbed the harmony of the group by trying to copulate. When the breaking up of the group began, several females as well as males were sex conscious.

It was impossible to estimate even approximately the relative number departing from the group by flight as against those crawling away, but several adults showed no desire to fly, either mating on the bush or departing through the long grass to other suitable spots, with the result that the number of single adults and mating couples feeding on and beneath the bottle tree increased daily. It may be that the delay in migration, caused by the wet weather, gave opportunity for the instincts of hunger and sex to become active and inhibitory to the impulse to fly, but a few cases were witnessed in which individuals took to flight after feeding and even after attempting copulation. Therefore it seems more probable that any moulting group of fifth instar nymphs comprises some individuals that have an inherent desire to fly, and other individuals in which such desire is absent. There is no clue at present to the ultimate cause of this difference in behaviour in *Dysdercus*; outwardly both kinds appeared the same. In this connection, it is interesting to note that several badly deformed adults were seen to go through all the preliminaries to flight. There seemed to be no corporate action influencing the individual, each one departing without reference to the rest of the group.

The characteristic movements preceding flight, as well as the flight itself, were somewhat different in the two sexes. For half an hour to an hour before setting off the male showed great restlessness at short intervals by stamping his forefeet, scratching his back, quivering, and opening his wings. He also changed his position frequently, moving from the tip of one twig to another. The female showed the same kind of signs, but her restless movements were separated by long periods in which she remained quite still, though she might change her position several times. In both cases the migration impulse appeared to affect them very suddenly, for they detached themselves from the sluggish mass and rushed precipitately to the top of the bush, where they began to exhibit the first signs of restlessness. Although they chose the upper and outer twigs of a small bush, they were never seen to take flight from a point higher than two yards from the ground. They always deposited excretion once during the preliminaries, which often was done a few minutes before flying. The final position of the body was at an angle of 45°, with the antennae stretched straight out in a line with the body. The flight of the male was higher and freer than that of the female, which suggests that he may travel farther afield. Often he was seen to rise in a spiral movement above the bush to such a height that he was lost to view before he had chosen his final direction, but other males approximated more nearly to the low straight flight of the females, which frequently made a number of short flights in the same direction before venturing on the longer journey. Of the total number of flights watched, 143 were towards the east, while 35 were divided between the other three directions of the compass. The bush from which they

set forth was more open to the sky on the east and west, and consequently the sun's rays fell slantingly upon it both morning and afternoon, but the shade of the bottle tree covered it during the middle of the day. From 11 a.m. to 4 p.m. migratory movements, as well as all other activities, slackened considerably, and there was only a partial renewal in the late afternoon. Just before sunset the bush invariably showed a large number of adults poised for flight, of which the majority were faced towards the west, but they seemed to doubt the wisdom of departing before nightfall and retired again to the bottom of the bush before dark. Not only did the sun seem to influence the direction of their flight, but as can be seen on the graph, sunshine appears to be a direct stimulus to flight, which fact is in line with other observations, reporting general activity to be partly dependent on sunshine.

During the migration period, the relative numbers of males and females present under the observation tree and in the new breeding grounds were estimated as accurately as possible, with a rather astonishing result. To begin with, we referred to the laboratory records, which gave the following numbers for the months November to February: Total number of adults bred, 1,619, of which 808 were male and 811 female, and the number of broods in which the females predominated was 44 out of a total of 83 broods. We concluded, therefore, that in the field during those same months the sexes were roughly balanced, and it was expected that there would be the same balance in the numbers migrating. But this was not so. From the one big group that was watched almost continuously from the beginning to the end of the migration (as recorded on the graph) only 45 females, as against 133 males, migrated. At first it seemed unlikely that in this respect the group could be regarded as typical of the other groups, and we expected the numbers to be reversed in other cases, but as the migration gradually came to an end, with the breaking up of the groups under the trees, females were everywhere in excess from 8th to 12th March, both up the tree and on the ground. Also two other bottle trees from which migrants had gone forth showed during the same period a similar excess of females left behind. Though it would be hard to prove the fact, yet it seems almost certain that females that have left their moulting group to wander and feed in the old breeding-ground will not migrate but will depend upon the arrival of new males from some other migration area. In the new breeding-grounds in the Washpool Gulley throughout a distance of one and a half miles, several counts were made of the relative numbers of the sexes in each group found feeding together under a single tree, and the numbers clearly showed that males were largely in excess from 1st to 6th March. But from 7th to 14th March the balance gradually turned in favour of the females, until they came to be very clearly dominant. Many more simultaneous counts would have to be made at the bottle trees on the ridge and at the new breeding-grounds in the Gully before any deductions could safely be made, but it is possible that there is some connection between these apparently contradictory numbers and the higher and freer flight of the males, which could cover greater distances than the females and so bring about the fertilisation of females belonging to another group.

To make more definite our observations on the movements of the migrants, we decided to mark adults in some of the later moulting groups under the observation tree by putting waterproof paint on the scutellum. Different colours were used, as follows, to represent the different dates of marking: 8th March, 100 black; 9th March, 200 red; 10th March, 300 blue; 11th March, 350 blue; making a total of 950. Subsequent searches gave the following results, which are noted on the accompanying map: 12th March, a blue male in copulation with an unmarked female was found on a patch of *Abutilon* in the Washpool Gully approximately ¼ mile north-east of the tree, and a blue female in copulation with an unmarked male was found a little further east; 13th March, two black females both in copulation with unmarked males were found still further east under shady trees approximately ½ mile from the tree feeding on *Abutilon*; 14th March, a single blue female was

found in the same situation as those of 12th March ; 15th March, a blue male in copulation with an unmarked female was found on a large patch of *Sida subspicata* in the gully to the north-west of the tree, approximately a quarter of a mile from the tree ; 17th March, a single blue male was found again in the same situation as those found on 12th March.

Such marking therefore supported our previous deduction, namely, that the Washpool Gully for a distance of at least one mile from the railway bridge to the east was being stocked with migrants from the bottle trees in the scrub at the western end of the ridge. Whether or not the first flights took the migrants further to the west and east of this portion was not discovered at the time, though observations made some weeks later proved that by then they had extended to the west beyond the railway line to the point at which the Gully loses itself in the open plain.

Work should be carried out through another season to disentangle the primary migration flights from the subsequent flight movements of the migrants. Observations made this year indicate that there is a first true migration flight (restricted to certain individuals in a brood), which may be to a distance of one mile and seems to have as its objective a new breeding-ground alongside a water-course, but this initial flight may be followed almost at once, or after an interval for feeding and copulation, by shorter flights from one food patch to another. A few of the secondary shorter flights were witnessed, and there were no signs of the long nervous preliminaries characteristic of the primary flight. It would seem that these subsequent flights are influenced entirely by a search for food or a mate and may lead up and down the water-course or out from it into the forest country on either side. Such a theory seems at present to fit best the facts (1) that during the first three weeks of the migration *Dysdercus* adults were found only under the shade trees along the Gully ; (2) that certain food patches under these shade trees carried a large number of pairs in copulation and were often deserted a week later ; and (3) that during the 4th and 5th weeks the bugs were found on different food-plants out in the forest country to a distance of a quarter of a mile from the Gully (*Abutilon oxycarpum*, *Sida retusa*, *Sida subspicata*, *Malvastrum*).

The migrants arrived in the cotton during the third phase of the migration, when cotton functioned as only one of the available food-plants, with no specially attractive power. They were found on 15th March on the cotton at the northern end of the Government Farm and two days later they were on Lehmann's cotton and on the cotton at the extreme southern end of the Farm. Lehmann's cotton had carried open bolls since 28th February, and in one part of his field a patch of *Abutilon* on 8th March was carrying 50 pairs, 15 single females and 52 single males within a yard of cotton bushes bearing open bolls. Having arrived in the cotton, they probably stayed there until the end of their adult life, laying several batches of eggs. The food and sex hungers of the majority would have been satisfied within the area of the crop, secondary flights after egg-laying being from one part of the field to another.

The appearance of nymphs in the new breeding-grounds was predicted accurately by the time-temperature charts of the Laboratory. Second instars were found as several large broods under different shade trees in the Gully from the 12th onwards. These were feeding on the ripe seeds of *Abutilon* on plants that had been in many cases deserted by the adults, which preferred the green fruit. In one case, eggs were found in the soil at the base of an *Abutilon* plant, on which a solitary deserted female was sitting. New partners seemed to be found after each egg-laying, for old and young mated indiscriminately.

In that part of the Gully between the cotton fields of Lehmann and Taylor many large broods of third and fourth instars were found at the time when second instars made their first appearance in the Gully between Lehmann's cotton and the railway

bridge. Such nymphs were regarded as the descendants of migrants that had moved west from the scrub near the cross-roads at a date a few weeks earlier than that of the migration from the ridge. Subsequently it was quite impossible to distinguish between the migrants from these two areas, as the two streams intermingled during the secondary flights.

On 11th March visits were paid to five neighbouring farms to investigate reports that *Dysdercus* adults had appeared in the cotton fields during the previous week. Messrs. Anderson and Van Itallie were visited first and fresh-looking adults were found fairly thickly spread over the bushes at the southern end of the field, and only thinly spread over the central portion, with none at all on the bushes at the northern end. This distribution suggested that they had come out of the deep gully through which the Callide very occasionally runs at flood time, and that their movement into the cotton was a secondary one, following the true migration flight possibly from the dense scrub to the south-east of the farms. The forest country around the farms on the north bank supported very few food-plants, but when the bed of the Callide was searched adults were found there feeding on *Sida retusa*.

At Messrs. W. and C. A. Thompson's farms bottle trees were found in close proximity to the cotton, but although adults and nymphs of all instars were found under some of the trees, not a single *Dysdercus* was seen on the cotton, which was open and ready for infestation. The fruiting of the bottle trees was over and the general appearance of the trees pointed to earlier migrations having taken place, leaving the usual percentage of stay-at-homes. The true migration flight must have carried the newly-moulted adults away from the cotton immediately adjacent.

Mr. Taylor's cotton was planted on ground cleared by the burning of the scrub, and as is common in such cases *Abutilon* was growing thickly among the cotton. *Dysdercus* adults and nymphs of all instars were found on the *Abutilon* very generally, but on the cotton plants more sparingly. One *Abutilon* plant that had pushed its way up through a cotton bush carried several pairs of *Dysdercus* in copulation, while the cotton, though open, was unattacked.

These observations confirmed our opinion that so long as there was a plentiful supply of other food-plants in the right stage of development cotton would remain only one of the many possibilities, with no superior attraction. Observations made by Mr. Currie, Assistant Entomologist, who continued the work during April and May, gave further support to the statement, for *Dysdercus* was found in large numbers in the forest country under shady trees (barcoo wattle and broad-leaved iron-bark) feeding on Malvaceae adjacent to cotton fields.

Special attention was given to the movements of *Dysdercus* on the Government Farm. The senior author noted the heaviest infestation to be along the southern edge of the crop as from 17th to 28th March, and Mr. Currie reported that such a distribution prevailed throughout the remainder of the time that migrants were on the wing. The senior author witnessed several of them flying in a north-westerly direction from the Gully to the cotton. Traps were set along the southern fence and caught considerable numbers daily until 6th April, when the movement into the crop came suddenly to an end, as shown by the fact that during the next two weeks not a single *Dysdercus* was found in any trap.

Not only did the time-temperature charts predict accurately the first appearance of nymphs in the Gully, but also the time at which these F_1 descendants of the bottle tree migrants were in their turn preparing for migration. From 20th to 30th April out under the shade trees in the forest country and in the cotton fields too, characteristic groups of sluggish fifth instar nymphs and newly moulted adults were clustering together in the cracks of bark, under fallen logs and on fence-posts. At the same time, under the bottle trees the corresponding descendents of the stay-at-homes were going through the same process. On 15th May, 179 of these newly moulted

Number of Individuals observed to take flight.
30
20
10
Insects in a mass; 30% adults not feeding.
No movement away from mass. No feeding or drinking. No sex-consciousness.
1♂ 2♀♀ moving away from bush thro' grass
2 adults feeding
1♂ sex-conscious
Shadow.
Sunshine.
Rain.
No observations for 1 hour
No observations for 1½ hours
No observations for 14 hours
Several adults moving away from mass through grass; 3 adults feeding a.m.; many p.m.; none in cop. a.m.; 6 pairs p.m. at bottom of bush. No sex-consciousness in those preparing for flight.
No observations for 1 hour.
Much movement from bush; many feeding. Several in cop.; ♂♂ sex-conscious just before flight.
No observations for 5 hours
Much movement and feeding. Pairs in cop.; ♂♂ and ♀♀ migrants sex-conscious.
Great activity on bush. Preparing to fly.
No further continuous observations.
Migration continued slowly; large number of adults scattered in grass.
Numbers on bush depleted but an occasional flight seen.
Same bush being used by another batch which moulted beside it.
2.III.27
3.III.27
4.III.27
5.III.27.
6.III.27
7.III.27.
8.III.27
9.III.27
10.III.27
6a.m. 7a.m. 8a.m. 9a.m. 10a.m. 11a.m. 12 Noon 1p.m. 2p.m. 3p.m. 4p.m. 5p.m. 6 p.m
8a.m. 9a.m. 10a.m. 11a.m. 12 Noon 1p.m. 2p.m. 3p.m. 4p.m. 5p.m. 6p.m.
8a.m. 9a.m. 10a.m. 11a.m. 12 Noon 1p.m 6p.m. 7 p.m
7a.m. 8a.m. 9a.m. 10a.m. 11a.m. 12 Noon

adults were marked beneath the observation tree, and on 10th May one of them was found on a patch of *Abutilon* in the Washpool Gully (see Map), proving that a second migration was in progress.

No newly moulted adults were marked at this time in the cotton field, and consequently it is not known whether the primary flights there carried the migrants away out of the crop into the surrounding forest country and neighbouring cotton crops. This seems possible in view of the fact that the primary flights in the case of the first migration were away from an abundant and satisfying food supply.

A spell of cold weather lasting for four days during the second migration had a definitely retarding influence, the extent of which was made clear by the behaviour of the individuals of one group, which were marked. For those four days they remained in exactly the same positions without moving at all, but then under the influence of returning warmth they scattered for food, and tended to return again to the same place each day, until the group was finally broken up about three weeks later.

With the advancing winter, might there come a time when there would not be sufficient warmth to induce migration, and if so, what would be the fate of the last moulting groups of the season ? Their behaviour in the Laboratory leads one to think that they may live for months in such sluggish groups, eating and drinking very little, so that with the coming of warmer days many of them may mate and lay eggs, provided that they find sufficient food.

It has been difficult to obtain exact information about the fruiting seasons of the various members of the Sterculiaceae. Until this knowledge has been obtained, it is perhaps premature to suggest that such members of the family as the kurrajong (*Brachychiton populneum*), which has been reported as flowering in the early spring, may provide the food upon which *Dysdercus* can breed rapidly during the weeks of returning warmth. It is important to note that the kurrajong, in contrast to the bottle tree, is found in forest country. Other members of the family flower in midsummer, of which the bottle tree observed this year was an example, but there seems to be some doubt as to whether bottle trees flower every year.

Further work during the coming season should discover some of the unknown facts about which we can only speculate. We hope to elucidate the following problems :—

(1) Water-courses as probable connecting links between breeding-grounds in the scrub and the cotton fields.

The work at Biloela suggests such a connection, and reports sent to the senior author from the Lockyer Valley this year indicate that crops at the head of the Valley near scrub country on the ranges were infested early, whereas those farms situated further down the Valley were free from *Dysdercus* until later.

(2) The fate of the clustering masses of adults left at the end of the season scattered widely through open forest country.

They may form centres of fresh infestation for the following season only under limited conditions of weather and food-supply, or they may altogether die out, leaving the scrub areas as the sole source of each season's infestation. The severe drought of 1926, which killed the forest food-plants, would account for their restriction to scrub areas early this year. The very heavy rainfall of December 1926 and January 1927 loaded the bottle trees with fruit and at the same time restocked the forest land with smaller food-plants.

(3) The distribution of the food-plants of spring and early summer, and possible substitutes for bottle trees in the years when these may not fruit or in places where they do not exist.

(4) The effect of climatic conditions on the quality and quantity of the food supply and on the time at which it becomes available, and thus the indirect effect of climate on the migration leading to the infestation of the crops.

8. Parasites and Predators.

Dysdercus sidae is controlled to some extent by Dipterous parasites, by a Reduviid, a mantis and by mites. The life-histories of these enemies have not been studied, and at the time of writing they are not yet identified. There appear to be two species of Diptera concerned,* which attack the adults, the larva making its way out when ready to pupate through the anus of its host. Curiously enough, parasitised bugs can live and run about for some hours after the parasite larva has left them, although their abdomens are completely collapsed (fig. 7).

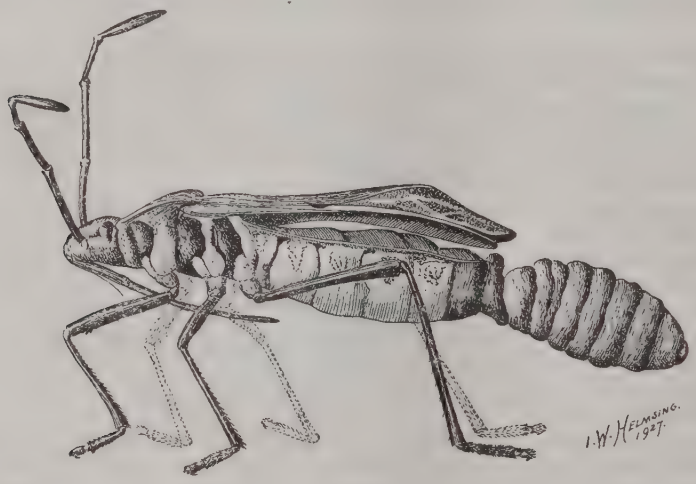


Fig. 7. Larva of Tachinid parasite emerging from adult of *Disdercus sidae*.

No egg parasites have been found.

The mites are still under investigation and little can be said about them at the moment, except that they cause the destruction of the wings and ovaries and would thus be one of the inhibiting factors affecting migration.

9. Control Measures.

The problem of controlling *Dysdercus sidae* under the conditions prevailing in Queensland has entirely defeated us.

The usual remedies of traps of cotton seed and destruction of wild food-plants and any suggestion of insecticidal control can be dismissed at once.

In a country where close settlement and intense cultivation existed, destruction of the winter food supply would seem the obvious control to apply, but while thousands of square miles of uncleared scrub and small isolated settlements are the rule in Queensland, no such method can be adopted.

* [These TACHINIDAE have since been described by Mr. C. H. Curran as *Alophora aureiventris* Curr., and *Catharosia varicolor*, Curr. (Bull. Ent. Res., xviii, 1927, p. 165).—Ed.]

Heaps of cotton seed, or far better, split kernels will attract nymphs which could be destroyed provided that the farmer were only cultivating one or two acres instead of from 15 to 50 or even more, and also provided that he had the time or the inclination to visit the traps and kill the assembled nymphs. In spite of the fact that the attractiveness of split kernels extends for some yards enormous numbers of traps would be required on the average holding, and for a farmer who employs no labour it would be an impossibility to visit the traps regularly.

Insecticides cannot be used for a variety of reasons, of which the most important is expense. Secondly, by the time *Dysdercus* comes into the cotton no horse-drawn machine could get into it. Any hand-worked machine is out of the question on large areas.

Anything which entails expense or the employment of labour cannot be considered in connection with the control of cotton pests in Queensland. The ideal thing would be to have a trap which automatically killed all *Dysdercus* which came to it, which would be furnished with a lure able to cover a wide area, which was cheap and fool-proof, and once set could be left for the season. This trap has yet to be devised. Moisture traps (which were tried) would only function in very dry weather. Cotton gives so much shade that playing upon the instinct to seek shade would not help. Split kernels form the most promising bait that has so far been found. These combined with poisoned water in a trap would kill nymphs, but would not kill enough to make it an economic proposition, and too many traps would be required.

There is another possibility, and that is making use of the gregarious instinct of the fifth instar nymphs when about to moult (Plate xix), by providing suitable collecting places for them, such as slabs of bark, and either destroying them by fire or by the use of some sticky material smeared on the inside of the shelter. So far we have found no type of tanglefoot strong enough to hold these nymphs. This is, however, a line worth following in another season. No definite conclusions could be arrived at in the present season (1926–27), as by the time the fifth instar nymphs had reached the stage when they began to cluster, the winter had begun and one could not be certain whether in the summer such large numbers would be obtained as were found in the shelters in the winter. Normally a cotton field does not provide the type of clustering place commonly used in the "bush," such as the trunks of rough-barked trees, fallen logs, etc. Judging from the use made of field cages by fifth instar nymphs* in the experimental cotton plot near Brisbane, the provision of moulting shelters does hold out some hopes of affording a means of control, provided that farmers could be persuaded to visit them and burn off the assembled nymphs. In any case the nymphs seem more easily caught than adults.

Several types of lure trap have been tried, but so far none has been evolved that is likely to appeal to the farmer. The materials for a trap must be such as are likely to be easily obtained on the ordinary farm, and it must be easy to construct.

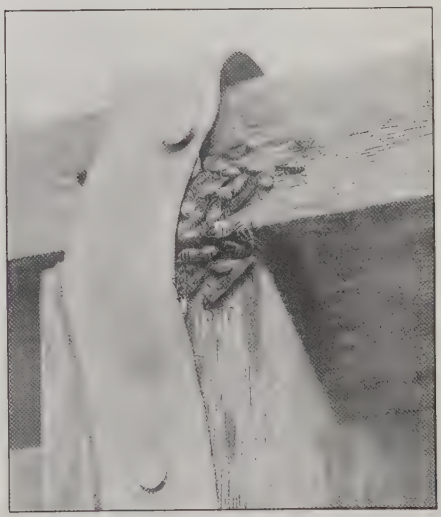
There, for the moment, the matter must be left, unless a chemist comes forward with a lure powerful enough to attract *Dysdercus* from a greater distance than any substance which we have so far found.†

We wish to acknowledge the assistance received from all members of the Cotton Section of the Department of Agriculture and Stock of Queensland in sending us data on the first arrival of *D. sidae* in their different districts, and in numerous other ways. We are indebted to Mr. I. W. Helmsing for the line illustrations accompanying this paper.

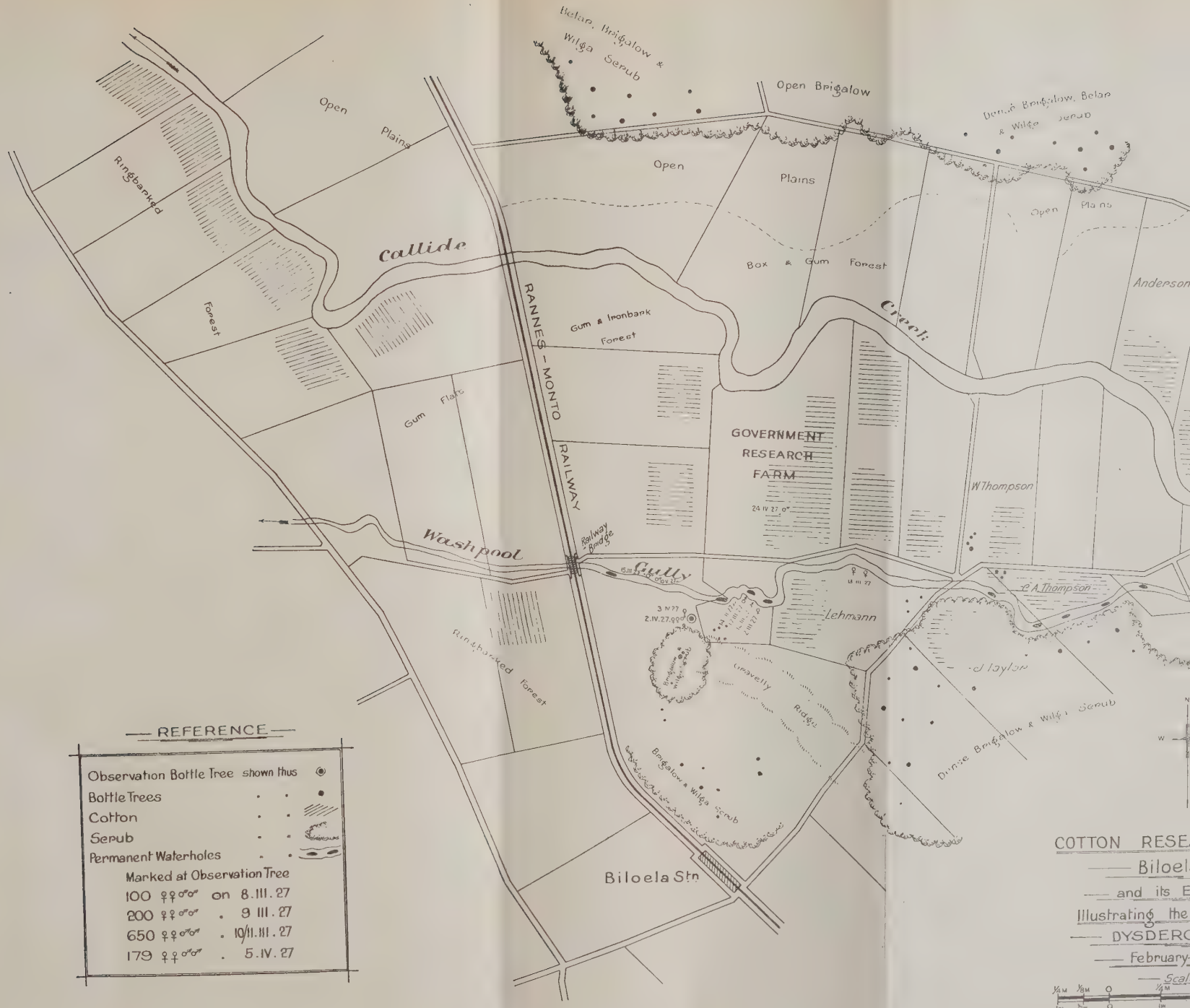
* Upwards of 1,000 nymphs collected to moult on one cage on a ¼-acre plot. In the rest of the field these fifth instars were comparatively rare. The cage was 6 ft. by 5 ft. by 5 ft.

† Substances tried as bait and found useless. Tarpineol, trimethylamine, amyl acetate, citronella, cotton meal, cotton seed oil (crude and refined), and moisture.

We particularly desire to thank Mr. Lloyd M. Hodge, Manager of the Cotton Research Station at Biloela, who was untiring in rendering help in every way, making traps, marking migrants, and doing all in his power to aid us. The members of his family also were of the utmost assistance in hunting for marked bugs in and around the farm while the observations on migration were in progress.



Clusterings of fifth instar nymphs, and adults, of *Dysdercus sidae*.


Open
Plains
Ringbarked
Forest
Callide
Belar, Brigalow & Wilga Scrub
Open Brigalow
Open
Plains
Box & Gum Forest
Dense Brigalow, Belar & Wilga Scrub
Open Plains
Anderson
Gum & Ironbank Forest
Gum Flats
RANNES - MONTO RAILWAY
Cypress
GOVERNMENT RESEARCH FARM
24 IV 27 0°
W Thompson
Railway Bridge
Washpool
Gully
15 III 27 0 0 0 IV 27
L A Thompson
Lehmann
3 IV 27
2 IV 27 90°
Ringbarked Forest
Gravelly Ridge
Brigalow & Wilga Scrub
Dense Brigalow & Wilga Scrub
Biloela Stn
REFERENCE
Observation Bottle Tree shown thus
Bottle Trees
Cotton
Scrub
Permanent Waterholes
Marked at Observation Tree
100 ♀♀♂♂ on 8.III.27
200 ♀♀♂♂ . 9 III .27
650 ♀♀♂♂ . 10/11.III.27
179 ♀♀♂♂ . 5.IV.27
COTTON RESE
Biloel
and its E
Illustrating the
DYSDERC
February
Scal

MOSQUITO BREEDING AND MALARIA IN RELATION TO THE NITROGEN CYCLE.

By K. B. Williamson.

Many anti-malarial workers have recorded the larval habitats of Anopheline species, and while their records usually reveal a variety of types of breeding-places for the same species even in one and the same country, the characterisation of the breeding waters usually lacks precision. This is hardly surprising, since descriptions are based upon naked eye observations, and only physical aspects of the breeding-places, or in addition only the most striking characteristics of the associated forms of vegetation are recorded, more or less casual information being given concerning the depth, clear or muddy character, and stagnation or currency, of the water, together with even more incomplete statements relating to the plants growing in or near it. The statement, not unimportant in itself, is, for example, often volunteered that larvae of a particular species are found in streams or pools with grassy margins, while information is usually lacking relating to the species of even the more conspicuous plants which grow in the water itself, and which are characteristic of it or of the presence of particular Anopheline larvae. For example, it has been found that in Malaya in ricefields on the flat coastal plain, the presence of the floating plant *Utricularia flexuosa* is widely associated with larval associations in which *Anopheles sinensis* predominates over *A. barbirostris*, other Anophelines being generally absent (Williamson, 1925). It seldom if ever happens, however, that an aquatic plant has the same range of adaptability as the associated mosquitos. For example, in the case quoted, *U. flexuosa* abounds over many square miles in the Krian rice-fields, from which all Anopheline larvae are absent, despite the proximity of their breeding-grounds; and conversely, *A. sinensis* and *A. barbirostris* are very commonly found unassociated with *Utricularia*.

The inability both of purely physical characteristics and of associated examples of the larger aquatic vegetation to serve as discriminants of water that is suitable for particular species of aquatic organisms, compels attention to other characteristics of the water. Both naked-eye algae and micro-organisms suggest themselves as possible discriminants. Records of association, positive or negative, with the former are at present very scanty, and knowledge of the microfauna and flora of mosquito-breeding waters is practically non-existent. Where positive correlations between the occurrence of mosquito larvae and particular algae have been recorded, they are usually casual, the larvae and the alga being found together at some times and places, and apart in others. The invariable association of *Culex bitaeniorhynchus* with an as yet unnamed species, or several species, of *Spirogyra* recorded by Senior White (1926, p. 219) is certainly an exceptional phenomenon; and no such association can be accepted as invariable unless it has been proved over a wide area, embracing diversified types of water. On the other hand, negative associations, in which the absence of all Anophelines, or of a particular species, is observed in the presence of a particular alga appear to hold good, with the above reservation that more extended observations may disprove them. An example of this in Malaya is the general absence of Anopheline larvae from water containing *Microcystis*. The blue-green mucilaginous packets of this unicellular alga form a dense scum an inch or two thick on the surface of the water, and though the plants have proved by experiment to be non-poisonous to certain species at least of Anophelines, larvae are incommoded, shaking off packets of cells too big to swallow, as though irritated. A dense scum is hardly compatible with the presence of Anopheline larvae, but the occurrence of this alga only in definitely foul water probably accounts for the general absence of Anopheline larvae in association with it. A similar explanation perhaps applies to the absence of Anopheline larvae from stagnant rice-fields containing another blue-green alga, *Tolypothrix* sp., in California as recorded by Purdy (1925).

These considerations suggest the possibility that chemical characteristics may be among the ultimate determinants of mosquito breeding, or its absence, in waters accessible for oviposition. The duration and intensity of radiation falling upon the water surface are indeed fundamentally important, since they determine the total of available food produced by photosynthetic activity, as well as the temperature of the water, which may approach to within about 2° or 3° C. of the thermal death point of exposed breeders even in the mild heat of Malaya.

Until recent years the chemical differences in mosquito-breeding waters received little or no mention. But MacGregor (1921) directed attention to their importance when he traced correlations between the hydrogen-ion concentration and the Anophelines present, observations which he has subsequently extended in Mauritius (1924). His lead has been followed, and together with a mass of pH data other chemical characters have been recorded.

Lamborn (1922) initiated chemical enquiry relating to Anopheline breeding waters in Malaya and published analyses by Blair, but he was unable from the few then available to deduce any certain conclusions. Also analyses made for Purdy (1925) failed to reveal larval correlations with either pH, dissolved oxygen, or mineral solutes. On the other hand, Senior White (1926) in Ceylon showed that the first two characters, and the concentration of solutes, approximately indicated by electrical conductivity, and in some cases the concentration of ammonia, were related to the specific distribution of Anophelines. Although owing to lack of laboratory facilities he was compelled to abandon the estimation of ammonia, and reluctantly to forego that of albuminoid matter, he recognised the special importance of the latter, after Hacker's observations quoted below.

There is, in fact, increasing evidence that the circumstances under which proteins are decomposed and the intermediate products of their transformation, modified by more or less complete oxidation, are important for aquatic animals (Harvey, 1925, 1926, 1927), especially fishes. The data given in the accompanying table relating to two species of Anophelines of contrasted chemical preferences, which yet occurred together in the same water, strikingly suggest that the same circumstances may also be important for Anopheline larvae. The figures are averages of certain organic and organically derived "factors"; and the principle of classification adopted is that of the predominance of the larvae of one or other of the two species. Of these, *Anopheles maculatus*, the chief carrier of malaria in hilly country in Malaya, while possessing great adaptability (*cf.* Senior White, 1926), typically breeds in very pure water derived from springs. The average of three analyses relating to the latter only are given for comparison in the first horizontal row. The main figures relate to weekly collections made by Dr. Hacker in ditches in Kent Rubber Estate in 1923–24. I am much indebted to him, and to Mr. R. Blair who analysed the water, for permission to make use of their data. Larvae of *A. kochi*, the second species dealt with, are found in stagnant, not seldom contaminated, water, as in buffalo wallows. The species is believed to carry little or no malaria in Malaya.

The example from Kent Estate has been selected because it includes the largest number of observations referring to two associated species. In reference to it Dr. Hacker (1923) made the important observation that larvae of *A. maculatus* were most, and those of *A. kochi* least, abundant when the albuminoid content of the water was least. Since solid albuminoid particles were included in the analyses, and since Anopheline larvae possess very little power of selecting floating food particles, it is improbable that the decrease of *A. maculatus* was due to diminution in the total quantity of food material. Apart from the possibility of seasonal conditions affecting the abundance or fertility of egg-laying adults, the fact that response to the changing composition of the water was recurrent and rapid justifies the conclusion that the latter had a direct effect upon the survival of larvae. And the figures in columns 5,

6 and 9 strongly suggest that the condition unfavourable to *A. maculatus* was defective oxidation in presence of excess of albuminoid matter. Since similar facts have been observed in the case of other associated Anopheline larvae (Williamson, 1927, 2), it is not improbable that changes occurring in the katabolic arc of the nitrogen cycle, in relation to the more or less complete oxidation of proteins and their derivatives, are an important, if not the chief, chemical cause determining the suitability of water for Anopheline larvae as a whole, as well as that of particular types of water for those of particular species.

1.	2.	3.	4.	5.	6.	7.	8.	9.
				Parts per million.				
	No. of Analyses.	Average no. of larvae of *A. maculatus*.	Per cent. larvae of *A. maculatus*.*	Albuminoid nitrogen by alk. & permang.	O_2 absorbed from acid permanganate in 3 hrs.	Oxidised nitrogen.	Ammoniacal nitrogen.	Ratio of oxidised to ammoniacal nitrogen.*
I. *A. maculatus* alone in springs ...	3	n.r.	100	Spring water for comparison. ·057	·395	·173	·026	8·78
II. *A. maculatus* alone in ditches in Kent Estate ...	14	133·5	100	Kent Estate. ·393	3·834	·209	·086	2·57
III. *A. maculatus* in majority ditto	15	60·1	76·5	1·304	35·541	·165	·085	2·32
IV. *A. kochi* in majority or alone (thrice) ditto ...	13	15·3	34·4	1·96	63·907	·170	·206	1·34

Water unfiltered and uncentrifuged. II, III, IV, from Kent Rubber Estate.
A few larvae of other species found there on 7 occasions not averaged.
* Averages of individual weekly figures.

Similar characteristics appear to differentiate the kinds of water suited to other aquatic animals. For example, Anopheline larvae, while differing specifically *inter se* regarding the degree of purity, as above defined, which they require, have about the same range of tolerance as fish, those which occur in the purest water being analogous to the SALMONIDAE. SIMULIIDAE also breed in pure and well oxygenated water, in contradistinction to PSYCHODIDAE and many, but not all, Culicine mosquitos and CHIRONOMIDAE. Batchinsky's (1927) observations afford general confirmation regarding the preferences of the CULICIDAE, but it is not clear from the summary just to hand that he has distinguished their specific preferences and degrees of tolerance of impure water, nor what his criterion of impurity is. Since a sufficiency of their proper food is as important for all organisms as the total remaining chemical

characteristics of the water, the chemical factors above outlined probably operate largely through determining the quality of the food, especially when this consists, as is the case with mosquito larvae, partly of detritus. For the latter's content both of bacteria and of nitrogenous derivatives is respectively modified or determined by antecedent occurrences in the nitrogen cycle, controlled among other things chiefly by oxidation and by chemical activities of the bacteria themselves. It may be surmised that pure-water species are adversely affected by the nitrogenous derivatives in foul water, present either in solution, or, more particularly, in their food, or else by some of the associated micro-organisms swallowed with the food. Foul-water species, on the other hand, being mostly gross feeders, are probably starved in relatively pure water, to which they may otherwise be constitutionally ill adapted. The complexities of the problem must be unravelled piecemeal for each species; and while co-operative biological and chemical enquiry is in progress relating to some of the local Anophelines, investigation on those lines in other countries, where conditions differ materially from those in Malaya, are needed before general conclusions can be established. The solution of the Anopheline problem thus envisaged, and otherwise so important, promises to throw light upon questions of profound bionomic interest, presenting close analogies with those which rule in other branches of hydrobiology.

Since lack of association of two aquatic organisms cannot with certainty be attributed to chemical differences in their environment, until its physical conditions have been investigated, including those which impose barriers to migration, or which affect the adults of the species, such as aquatic Diptera, which pass only their developmental stages in the water; limitation of inductive reasoning, as in the above example, to groups of species found associated in the same water, is the only sound preliminary procedure. A graph, unsuited for reproduction on a small scale, shows fluctuating correlations between the percentage of larvae of *A. maculatus* and the principal chemical variants, and reveals the further fact that during certain periods the larval maxima and minima lag a few days behind the corresponding points on the chemical curves. Since the past history of the water rather than what it is at the time of collection is what matters, this result is to be anticipated whenever conditions change within a critical range of variation. And the need for caution is indicated in deducing from single observations the suitability of water for even comparatively short-lived organisms.

Detailed interpretation of the results tabulated above must necessarily remain speculative until the "sound body of theoretical knowledge" for which Harvey pleads has been created, but:—

1. The importance of efficient oxidation of the products of protein-lysis is shown by the fact established by Harvey (1925) that putrefactive changes in peptone generate a filter-passing poison, effective in the absence of the bacteria which attended its origin; while absence of putrescence, and efficient oxidation by photosynthesis, aeration, or addition of hydrogen peroxide, are generally recognised as necessary for maintaining healthful conditions in aquaria and Anopheline larvaria.

2. The ratio between oxidised and ammoniacal nitrogen given in column 9 which may appropriately be termed the *nitrification ratio*, is perhaps new to hydrobiology. Its discriminative value, which, though it sometimes fails, has been found to be fairly wide in the case of other mutually associated Anopheline larvae also, may probably be explained by the fact that oxidation of ammonia proceeds *pari passu* with, and under approximately the same conditions as, profounder oxidations of proteins and their more complex derivatives.

It may at first seem paradoxical to expect that a mere numerical coefficient, itself devoid of causal significance, should be a better discriminant of biochemical equilibrium than even an efficient causal factor considered singly. Yet this is to

be expected if, as is assumed in the present case, the discriminant chosen expresses the balance between a group of important causal factors, the effect of each one of which is modified by the others. Moreover, even if several out of a complex of interacting factors, such as those which determine oxidations, is known, their resultant effect must remain unpredictable even on the chemical plane, until the world of fermentative activities is revealed in its dynamic aspect, and a calculus for dealing with it is evolved. A discriminant is a short cut to the answer. Such should therefore be sought for other processes also, as for example, in reference to carbohydratelysis and peaty transformations. The nitrification ratio is far from being a perfect discriminant, and cannot be expected to serve except in shallow water. For the fact is well established that algae deplete the surface layers of deep water of nitrates in summer (Harvey, 1926; Orr, 1926; Domagalla, Juday & Peterson, 1925). But in shallow water mixing is continuous and practically perfect, so that the ammonia which is found in the bottom layers (Domagalla, 1925), and which is presumably derived from decomposition occurring in the underlying sludge, is brought to the surface and oxidised, if the competition for oxygen is not too great. Algae by their photosynthetic activity doubtless help to recreate nitrates in place of those they have absorbed, so that a balance is struck with ammonia which is in a measure characteristic of the water. The subject needs further investigation by sensitive methods applicable in the field. Theoretically, better discriminants should be the rate of nitrification compared with the concentration of ammonia present, or possibly the relation of the oxidation-reduction potential of the water to its albuminoid content. It will be seen that, in the example quoted, the ratio of nitrates to albuminoid matter also possesses discriminative value, as does the concentration of ammonia present (Senior White, 1926, p.198). Nitrites, which are absent or present in mere traces in most Anopheline breeding-waters, should also serve as indicators of their nitrogenous equilibrium, if estimated by a sufficiently delicate method.

3. The case of dissolved oxygen is instructive. It possesses discriminative value (Senior White, 1926; *cf.* per contra Purdy, 1925), not so much because it is a causal factor, providing one essential condition for oxidation, as because it is a labile substance, the residual concentration of which at any moment is an index of the pre-existing balance between the demand for, and the supply of, oxygen. But the ratio of dissolved oxygen either to protein or to ammonia should constitute a better discriminant than itself alone. Neither the dissolved oxygen, nor the pH, was determined in connection with the observations above tabulated; but the variation of pH in the ditches was probably between 5·5 and 6·5, limits unlikely to be harmful to either species concerned. The correlation between hydrogen-ion concentration and the larvae of certain other Malayan Anophelines has been shown to differ in different types of water (Williamson, 1925), or, in other words, to have been dependent upon associated factors, the chief of which were stagnation and rot. And the following considerations go far to prove that the hydrogen-ion concentration is not in itself an efficient cause appreciably and directly affecting Anopheline larvae within its ordinarily occurring range of variation.

For not only have various observers recorded wide natural ranges of pH for a number of Anopheline species, but also abundance of larvae has been found at widely differing extremes (Barber, 1924), a fact in agreement with Malayan records. In the case of *A. barbirostris* in particular, larvae of all ages have twice been found in maximal abundance at pH values of 5·2 and 5·3 (residual pH after expulsion of carbon dioxide 5·9) respectively, while also very abundant at a pH of about 8; while *A. separatus*, the alkaline limit of occurrence of which is unknown, continued to breed abundantly for months in ditches with a pH at or below 3·6 (residual), the brom-cresol green indicator used failing to indicate lower values. If hydrogen-ion concentration directly and alone determined larval prevalence, maximal abundance should occur at about the middle of the natural range of a species; and its occurrence

at the observed extremes precludes the possibility that these are limiting values, or even very near them.

Among associated factors, micro-organisms, whether serving as larval food (Lamborn, 1922), or producing disease (MacGregor, 1921) are probably of primary importance. Lamborn (*loc. cit*, p. 130) has also drawn attention to the probably beneficial effect of *Euglena*, upon which his larvae fed, in purifying foul water by photosynthetically-generated oxygen.

The bearing of the above conclusions upon anti-malarial practice cannot be discussed here. Suffice it to say that as long ago as 1911 Sir Malcolm Watson (1921, p. 213) suggested that dangerous species of mosquitos might be abolished by initiating a rural industry dependent upon the rotting of some fibre. Subsequent extensive field work (Williamson, 1925), and the line of research discussed, go far to confirm this view. Apart from such wide measures, called for in the interests of defenceless rural populations, contamination of stagnant ditches, etc. (for example, with dead fish) will effectually aid in clearing them of Anopheline larvae, as may be witnessed yearly during the fish harvest in Krian ; and Anopheline breeding almost ceases there during the months when heavy crops of reeds are rotted in the rice-fields.

The phrase dangerous species of mosquitos raises a further question of interest. It has been elsewhere argued (Williamson, 1927, 1) that many, if not most, of the more efficient malaria carriers breed in pure and well-aerated water, which, even if peaty, as is usually the case with the Malayan *A. umbrosus*, exhibits a low albuminoid content (average of three analyses 0·3 per million) and a high nitrification ratio (4·2 to ∞). And is it altogether an accident that other Protozoa which infest mammalian blood, while apparently failing to complete their cycle of development in the majority of blood-sucking Diptera, do so only in those otherwise unrelated Arthropoda, such as tsetse-flies, ticks, mites, lice, and exceptionally fleas, the entire trophic existence of which is aerial and uncontaminated by corrupting larval environment, probably a chief factor in this being bacterially rotted and infected food, which life-long blood-suckers like tsetse-flies escape ? Or again, is it without significance that vitamins originate in photosynthetically active green plants ? I believe that these questions relate to interconnected problems of nitrogenous metabolism, which, especially in the tropics, where the problems are both most varied and most urgent, deserve close attention, and promise objectives that may profitably occupy research for many years.

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